U.S. Department of Energy
Office of River Protection
P.O. Box 450, MSIN H6-60
Richland, Washington 99352

04-WTP-253

Mr. J. P. Henschel, Project Director
Bechtel National, Inc.
2435 Stevens Center
Richland, Washington 99352

Dear Mr. Henschel:

CONTRACT NO. DE-AC27-01RV14136 – APPROVAL OF BECHTEL NATIONAL, INC. (BNI) AUTHORIZATION BASIS AMENDMENT REQUEST (ABAR) 24590-WTP-SE-ENS-03-1144, REVISION 1, CESIUM ION EXCHANGE (CXP)-HYDROGEN MITIGATION/EMERGENCY ELUTION/FLOODED COLUMN DESIGN

Reference: BNI letter from J. P. Henschel to R. J. Schepens, ORP, "Transmittal for Approval: Authorization Basis Amendment Request 24590-WTP-SE-ENS-03-1144, Revision 1, CXP-Hydrogen Mitigation/Emergency Elution/Flooded Column Design," CCN: 090792, dated June 25, 2004.

This letter approves the referenced BNI ABAR, 24590-WTP-SE-ENS-03-1144, Revision 1, and transmits the associated Safety Evaluation Report (SER), which documents the U.S. Department of Energy (DOE), Office of River Protection (ORP) evaluation of proposed changes in the ABAR. The ABAR proposes design changes to the CXP columns with respect to the hydrogen mitigation and emergency elution systems. This ABAR also addresses the standards evaluation and selection process for CXP structures, systems, and components based on the implementation of DOE Standard 3009 safety classification methodology. This SER conditionally approves the ABAR. These conditions of acceptance have all been extensively discussed with BNI and were described in detail in SER Section D.

Based on the information in the Reference letter and the attached SER, the proposed changes are acceptable and there is reasonable assurance that the health and safety of the public, workers, and the environment will not be adversely affected by the approval of the ABAR. The approval complies with applicable laws, regulations, and River Protection Project Waste Treatment and Immobilization Plant (WTP) contractual requirements.

The attached SER provides final approval for the facility design changes as described in the ABAR, but only interim approval of the proposed specific changes to the Pretreatment (PT) Building Preliminary Safety Analysis Report (PSAR), Revision 1. Final review and approval of the specific PSAR changes will be made at the time of PSAR update when accompanying revisions to Chapter 2 are provided. As a result, only interim approval of the specific PSAR page changes is provided in the attached SER. The specific changes to the PSAR include revisions to relevant hazard and accident analysis, important to safety structure, system, and component selection, and derivation of technical safety requirements. This amendment is effective immediately and shall be fully implemented within 30 days; i.e., the provisions of the amendment may be used immediately.

The proposed changes to the Safety Requirements Documents (SRD) associated with the ABAR are effective immediately and shall be fully implemented within 30 days; i.e., the provisions of the amendment may be used immediately. Within 30 days, controlled copies of the SRD must be modified to reflect the proposed changes associated with this ABAR.

If you have any questions, please contact me, or your staff may contact Lewis F. Miller, Jr. WTP Safety Authorization Basis Team, (509) 373-9189.

Sincerely,

Roy J. Schepens
Manager

WTP:KC

Attachment

cc w/attach:
M. T. Sautman, DNFSB
J. M. Eller, PAC

Safety Evaluation Report (SER)
of Proposed Authorization Basis Amendment Request (ABAR)
24590-WTP-SE-ENS-03-1144, Rev. 1
to the Safety Requirements Document (SRD)
and Preliminary Safety Analysis Report (PSAR)
for the River Protection Project Waste Treatment and Immobilization Plant (WTP)

A.0 INTRODUCTION

The WTP authorization basis is the composite of information provided by the Contractor in response to radiological, nuclear, and process safety requirements that is the basis on which the U.S. Department of Energy, Office of River Protection (ORP) grants permission to perform regulated activities. The authorization basis includes that information requested by the Contractor for inclusion in the authorization basis and subsequently accepted by the ORP. The authorization basis for the WTP includes the SRD and PSAR. The SRD contains the approved set of radiological, nuclear and process safety standards and requirements, which if implemented, provide adequate protection for facility workers, the public, and the environment against hazards associated with the operation of the facility. The PSAR describes the analyzed safety basis for the facility (safety envelope), demonstrates that the facility can be operated such that the radiological, nuclear, and process safety requirements are met, and demonstrates adequate protection of the public, workers, and the environment. By letter dated June 25, 2004,[1] Bechtel National, Inc. (the Contractor) submitted a proposed amendment to the SRD and PSAR. This SER documents the ORP evaluation of the proposed changes in the ABAR.

B.0 BACKGROUND

The SRD contains a set of radiological, nuclear, and process safety standards necessary to ensure adequate protection of the health and safety of facility workers, co-located workers, the public, and the environment from radiological, nuclear, and process hazards. The PSAR is based on the preliminary design of the facility and is a part of the authorization basis for facility construction. Included in the development process of both SRD and PSAR is continuing review of industry practices, and review of the results of the process hazards and accident analyses as they evolve with the design of the facility for potential impacts on SRD standards and design evolution described in the PSAR to ensure adequate protection for facility workers and the public.

The ABAR 24590-WTP-SE-ENS-03-1144, Rev. 1, submitted to ORP by the Contractor proposes design changes to the Cesium Ion Exchange (CXP) columns with respect to the hydrogen mitigation and emergency elution systems. The ABAR also addresses the standards evaluation and selection process for CXP structures, systems, and components (SSCs) based on the implementation of DOE Standard 3009 safety classification methodology.

C.0 EVALUATION

The ABAR addresses changes to the hydrogen mitigation and emergency elution systems. As stated in the proposed changes to Sections 4.4.16 and 4.4.17 of the PSAR, the modified hydrogen

[1] BNI letter from J. P. Henschel to R. J. Schepens, ORP, "Transmittal for Approval - Authorization Basis Amendment Request 24590-WTP-SE-ENS-03-1144, Revision 1, CXP-Hydrogen Mitigation/Emergency Elution/Flooded Column Design," CCN: 090792, dated June 25, 2004.

mitigation and emergency elution systems will "prevent a potential deflagration or detonation" and "prevent resin heatup to the point of thermal degradation or auto ignition." The changes also include changes to the design, safety classifications, SRD safety criteria, standards, and the PSAR. The safety classification changes, SRD safety criterion changes, and standard changes result from implementing DOE-STD-3009. The drawings referenced in the ABAR were not evaluated for approval because the drawings are not part of the WTP authorization basis; however, the drawings were used to understand the proposed changes. Proposed changes to CXP safety classifications are evaluated in Section C.1, and SRD safety criteria and standards changes are evaluated in Section C.2. Section C.3 contains an evaluation of the proposed changes to the PSAR.

C.1 Proposed Changes to CXP Safety Classifications

As a result of the new design changes to the CXP hydrogen mitigation and emergency elution systems, a new safety classification for CXP SSCs was proposed in the ABAR. The proposed new safety classification scheme is consistent with DOE-STD-3009. The Contractor has adopted the new safety classification scheme for Important to Safety (ITS) SSCs as described in SRD Safety Criterion 1.0-6. This classification scheme has three sub-classifications: Safety Class (SC), Safety Significant (SS), and Additional Protection Class (APC). The Contractor stated that, although safety requirements for worker protection under the new SC/SS/APC safety classification scheme are less stringent than that under the old SDC/SDS/RRC safety classification scheme, adequate safety is still maintained since the new safety classification scheme implements the requirements of DOE Order 420.1, which provides the DOE top-level guidance for facility safety.

C.1.1 <u>Cesium Ion Exchange (CXP) Column Safety Classification:</u>

The ABAR proposes the following change: "The safety classification for the CXP columns will be changed from Safety Design Class (SDC)/Seismic Category (SC)-I to Safety Significant (SS)/SC-III and their safety functions are revised to include maintaining an intact connection with the emergency elution and nitrogen inerting systems."

<u>Required Modifications:</u> To provide clarity, the proposed change above must be deleted and replaced with the following: "The safety classification for the CXP columns and their associated valves and piping will be changed from SDC/SC-I to SS/SC-III."

<u>Evaluation (Acceptable as modified):</u> The CXP columns and their associated valves and piping are designed to maintain structural integrity, considering the high radiation environment where they are operated and the corrosive and erosive nature of the process streams. The columns and their associated valves and piping will maintain their structural integrities under abnormal and accident conditions. The safety function of the columns and their associated valves and piping is to provide a confinement boundary for mitigating the following identified accidental design basis events (DBEs): resin dry-out and overheating due to CXP column leakage, over-concentration of elution acid in the CNP or emergency elution systems, and detonation or deflagration caused by hydrogen accumulation in the CXP columns. The worst unmitigated consequences for these DBEs are estimated by the Contractor to be severity level (SL)-2 to the public, and SL-1 to workers and co-located workers. Based on the safety classification methodology defined

in Section 6.0 of Appendix A of the SRD, the CXP columns and their associated valves and piping are therefore designated as SS. The reviewers have reviewed the consequence calculation and found acceptable the proposed safety classification of the CXP columns and their associated valves and piping because it is consistent with this methodology.

C.1.2 Nitric Acid Concentration Monitors and Interlocks:

The nitric acid concentration monitors and interlocks will be changed from SDC to Additional Protection Class (APC).

Evaluation (Acceptable): The credited safety function of the nitric acid concentration monitors and interlocks is to prevent the transfer of greater than 3M acid into the CXP columns during elution. The addition of over-concentrated acid in the CXP columns could cause exothermic reactions with the resin and produce large amount of gas and release radioactive materials. It was estimated by the Contractor that the unmitigated consequences for this event are SL-2 for the public, and SL-1 for workers and co-located workers. The two independent physical barriers for the event are the CXP columns, and cell structures plus the C5 ventilation system. In addition, there are several other SS controls such as the column temperature monitoring element (sensor) and the emergency elution system for preventing the event (see Section C.1.3). The reviewers agreed that the acid concentration monitors and interlocks can be designated as APC to provide additional protection for the event.

C.1.3 CXP Column Liquid Level Protection System:

The CXP liquid level protection system will be replaced with an emergency elution system as a control strategy for the column resin dry-out and overheat DBE. The emergency elution system will be designated as SS/SC-III.

Evaluation (Acceptable): The credited safety function of the CXP emergency elution system is to remove the adsorbed Cs-137 from the column and maintain the column at a liquid level sufficient to prevent resin overheat that could lead to thermal degradation or auto-ignition of the resin. The emergency elution system includes:

- Column resin bed temperature monitoring instrumentation;
- Emergency elution system interlock;
- Column isolation valve interlock;
- Column feed pump valve interlock; and
- Vessels, piping, valves, and instrumentation associated with the emergency elution system.

The failure of the emergency elution system could cause the CXP column to overheat with estimated unmitigated consequences of SL-2 to the public and SL-1 to workers and co-located workers. Based on the safety classification defined in Section 6.0 of Appendix A of the SRD and seismic safety classification methodology defined in SRD Safety Criterion 4.1-3, the emergency elution system is therefore designated as SS/SC-III. The reviewers found this safety/seismic classification for the emergency elution system acceptable because it is consistent with the SRD safety classification methodology.

C.1.4 CXP Feed Cooler Tube Control:

The safety classification of CXP feed coolers will be changed from SDC to SS.

> Evaluation (Acceptable): The credited safety function for the feed coolers is to provide primary confinement of process liquids, the release of which could harm facility workers. Therefore, the feed coolers must maintain their structural integrities and withstand the high radiation environment, the corrosive effects of process streams, and the erosive nature of suspended solids in streams. A failed feed cooler could allow radioactive material to enter the chilled water system and cause direct radiation exposure to facility workers. This unmitigated accident scenario was calculated to cause no consequence to the public and co-located workers, and high radiological consequences to facility workers. Based on the safety classification defined in the SRD, the tube structure of feed coolers is therefore designated as SS. The reviewers reviewed the calculation and found the safety re-classification of the feed coolers acceptable because it is consistent with the SRD safety classification methodology.

C.1.5 CXP Feed Cooler Chilled Water Pressure Monitoring Instrumentation and Interlocks:

The safety classification of the CXP feed cooler chilled water pressure monitoring instrumentation and interlocks will be reclassified from SDC/SC-I to APC/SC-III.

> Evaluation (Acceptable): The credited safety function of the CXP feed cooler chilled water pressure monitoring instrumentation and interlocks is to shut down the CXP feed pumps on detecting low chilled water pressure, which indicates a reduction in the differential pressure between the chilled water and process vessel pressures. Reduced chilled water pressure could allow radioactive materials to enter the chilled water system if the feed cooler wall separating the process liquid and chilled water has failed. Facility workers in the vicinity of the radioactively contaminated water system could be exposed to direct radiation. The primary control to prevent this leakage of radioactive material into the chilled water system is the tube structure of the feed coolers. The only unmitigated consequence of this accident is direct radiation exposure to facility workers. The credited control strategy for this event is the feed cooler tube structure, based on the requirements defined in Appendix A, Section 5.2 of the SRD. Therefore, the reviewers agreed the other two controls for this accident, chilled water pressure monitoring instrumentation and interlocks, can be reclassified as APC.

C.1.6 Relocation of the Description of CXP Feed Cooler

The description of the CXP feed cooler will be moved from Table 4A-1 of PT PSAR to Section 4.4.15 of PT PSAR.

> Evaluation (Acceptable): Table 4A-1 provides a list of SDC SSCs of CXP system. Since feed coolers have been reclassified to be SS SSCs as discussed previously, they no longer belong to Table 4A-1. This proposed change is acceptable.

C.1.7 Relocation of the Description of Feed Cooler Chilled Water Pressure Monitoring Instrumentation and Interlocks

The description of the feed cooler chilled water pressure monitoring instrumentation and interlocks will be removed from Table 4A-2 of PT PSAR.

> Evaluation (Acceptable): Table 4A-2 provides a list of SDS SSCs of CXP system. Since the feed cooler chilled water pressure monitoring instrumentation and interlock have been reclassified as APC/SC-III as discussed previously, they no longer belong in Table 4A-2. This proposed change is acceptable.

C.2 Changes to SRD Safety Criteria and Standards Due to Implementing DOE-STD-3009

The ABAR describes the Contractor's ISM-based evaluation of the applicability of the SRD Criteria and Implementing Standards to the CXP system. Through its ISM process, the Contractor identified SRD Safety Criterion 4.1-4 and three SRD standards (Institute of Electric and Electronic Engineers (IEEE) 379, 344, and 323) that must be amended to incorporate the new safety classification scheme as described in SRD Safety Criterion 1.0-6. The reviewers identified additional SRD safety criteria and standards (Safety Criteria 4.4-3, 4.4-4, 4.5-1, 4.5-2, Appendix B, Section 5.4; Appendix C, Sections 12, 13, 17, 18, 19, 21, and 31) that must be amended to implement the new safety classification scheme for the CXP system. The Contractor has addressed these requirements in ABAR-24590-WTP-SE-ENS-04-0137. This ABAR is being reviewed by ORP.

> Evaluation (Conditionally acceptable): The approval of the ABAR-24590-WTP-SE-ENS-03-1144 is contingent on the approval of ABAR-24590-WTP-SE-ENS-04-0137. This condition of acceptance is further discussed in Section 4.4 of this SER.

C.2.1 Safety Criterion 4.1-4

The ABAR proposes to change the application of Safety Criterion 4.1-4 from "Structures, systems, and components designated as Safety Design Class" to "Structures, systems, and components designated as Safety Design Class, Safety Class, or Safety Significant (for worker protection)".

> Evaluation (Acceptable): As described in SRD Safety Criterion 1.0-6, the Contractor has adopted a new safety classification scheme for ITS SSCs to be consistent with the safety classification methodology of DOE-STD-3009. This new safety classification has three sub-classifications: SC, SS, and APC. SC SSCs include SSCs and portions of process systems whose preventive or mitigative functions are necessary to limit radioactive hazardous material exposure to the public as determined from safety analysis. The SS SSCs include SSCs not designated as SC SSCs, but whose preventive or mitigative functions are major contributors to defense in depth and/or worker safety as determined from safety analysis. APC SSCs include those important to safety SSCs that are neither SC nor SS. The addition of SC and SS SSCs to Safety Criterion 4.1-4 reflects the new safety classification scheme. The reviewers found this acceptable because it is consistent with the safety classification methodology of DOE-STD-3009.

C.2.2 Tailoring of Institute of Electric and Electronic Engineers (IEEE) 379 in the SRD

The ABAR proposes to change the applicability of IEEE 379 (as shown in Appendix C, page C.24.1 of the SRD) from "for SDC/SDS system design and operation" to "for SDC/SDS system design and operation; including SC/SS when single failure criteria are applied."

Required Modifications: For clarity, the proposed change must be modified as follows: In Appendix C, page C. 24-1 of the SRD, the words "for SDC/SDS system design and operation" shall be deleted and replaced with "for SDC/SDS and SC/SS system design and operation."

Evaluation (Acceptable as modified): The proposal would incorporate the new safety classification scheme of SC and SS to be consistent with safety classification methodology of DOE-STD-3009. The proposal would continue to require the use of IEEE 379 when single failure criteria are applied to SC and SS SSCs. The proposed changes as modified above do not represent any reduction in commitment to safety for the operation of the WTP. Therefore, the reviewers found the proposed changes as modified acceptable.

C.2.3 Tailoring of IEEE 344

The ABAR proposes to change the applicability of IEEE 344 (as shown in Appendix C, page C.22-1 of the SRD) from "SDC/SDS system design and operation" to "SDC/SDS or SC/SS Seismic Category-I electric and instrument design."

Required Modifications: For clarity, the proposed change must be modified as follows: In Appendix C, page C.22-1 of the SRD, the words "SDC/SDS system design and operation" shall be deleted and replaced with "SDC/SDS and SC/SS system design and operation."

Evaluation (Acceptable as modified): The proposal would incorporate the new safety classification scheme of SC and SS to be consistent with the safety classification methodology of DOE-STD-3009. The proposal would continue to require the use of IEEE 344 for seismic qualification of SDC/SC/ SC-I equipment, and would explicitly address SDS/SS equipment that is SC-II and required to function during and after a design basis earthquake. The proposed changes as modified do not represent a reduction in commitment to safety. Therefore, the reviewers found the proposed changes as modified acceptable.

C.2.4 Tailoring of IEEE 323

The ABAR proposes to change the applicability of IEEE 323 (as shown in Appendix C, page C.23-1 of the SRD) by adding to Section 1.1, Scope "This Standard applies to SSCs designated as SDC, SC, SDS, or SS (where SS SSCs is required to perform a credited safety function in a harsh environment)" and modifying Section 2 to read, "DOE/RL-96-0006, Revision 3, top-level radiological, nuclear, and process safety standards and principles for the RPP waste treatment plant contractor."

Required Modifications: For clarity, the proposed change must be modified as follows: In Appendix C, page C.23-1 of the SRD, the following must be added to Section 1.1, Scope, "This Standard applies to SSCs designated as SDC, SC, SDS, or SS." The proposed modification to Section 2 was not evaluated because the document DOE/RL-96-0006, Revision 3 is not part of the Contractor's WTP authorization basis.

Evaluation (Acceptable as modified): The proposal would incorporate the new safety classification of SC and SS, which is consistent with the safety classification methodology of DOS-STD-3009. The proposed changes require the application of IEEE 323 for environmentally qualifying SC and SS equipment. The proposed changes as modified do not represent a reduction in commitment to safety. Therefore, the reviewers found the proposed changes as modified acceptable.

C.3 Proposed Changes to PT PSAR (24590-WTP-PSAR-ESH-01-002-02, Revision 1, Preliminary Safety Analysis Report to Support Construction Authorization; PT Facility Specific Information: Sections 3.3, 3.4.1.7, 3.4.1.8, 3.4.2.1, Appendix 3A, Sections 4.3, 4.4, Appendix 4A, Sections 5.3, 5.5, 5.6, and Appendix 5A.

Proposed changes to specific PSAR sections in the ABAR are shown below, followed by required modifications (where necessary) and ORP's evaluation of the changes.

3.3.3.2.4 Control Strategies

- Explosions -~~ Temperature monitor and trip on contents of Cs evaporator~~; ~~a~~A reliable, seismically qualified vessel mixing and hydrogen purging system; ~~level instrument~~ Cs IX hydrogen mitigation system reverts lead column to safe state on low liquid level or high temperature indication; stopping reagent flow when the chemical concentration setpoint is exceeded; vessel contents verified within specification before reagent transfer; flow instrument opens purge air supply valve on loss of steam flow to evaporator~~; and an in-line radiation detector and interlock between the column and RDP vessels to prevent transfer of un-eluted resin~~.
- Fire - Columns instrumented with ~~level detection;~~ resin temperature monitors; ~~interlock to close fresh resin addition valve upon activation of emergency elution;~~ emergency elution system; and primary confinement components designed for worst-case service and seismic conditions.
- Spray leaks of radioactive material - Cs IX Hydrogen mitigation system ~~Level instrument~~ reverts lead column to safe state on high temperature or low liquid level; ~~and~~ primary confinement components designed for worst-case service conditions.

Required Modifications: As a correction, the following phrase in the first bullet in this section, *"Cs IX hydrogen mitigation system reverts lead column to safe state on low liquid level or high temperature indication;"* must be deleted and replaced with *"emergency elution system reverts lead column to safe state on low liquid level or high temperature indication;"*

Evaluation (Acceptable as modified): The reviewers concluded that the Cs evaporator temperature monitor and trip was not needed as a credited control strategy to prevent explosions as proposed because explosions are prevented by the new hydrogen mitigation system. The reviewers agreed that the level instrument in the obsolete hydrogen mitigation system was not needed as a credited control strategy to prevent explosions because the obsolete system has been deleted from the design. The reviewers agreed that the new hydrogen mitigation system was needed as a credited control strategy to prevent explosions due to hydrogen buildup from radiolysis and/or thermolysis. The reviewers agreed that (as modified) the new hydrogen mitigation system would revert the lead column to a safe state on high temperature indication. The reviewers agreed that the in-line radiation detector to prevent the transfer of uneluted resins to RDP vessels was not needed as a credited control strategy to prevent explosions because the tanks will be equipped with ITS purge air to prevent hydrogen buildup (24590-WTP-SE-03-1144, Rev. 1, Attachment 3, Section 3.3.5.2, "Direct Radiation"). The reviewers agreed that the level detection system and interlock to close the fresh resin addition valve upon activation of emergency elution were not needed as control strategies to prevent fires because the design of the new hydrogen mitigation system and emergency elution system obviates the need for these control features. The reviewers agreed that the level detection system was not needed as a control strategy to prevent spray leaks because the new hydrogen mitigation system (with its level detection capabilities) has replaced the former level detection system.

3.3.5.1.1 Contamination of Chilled Water System

In addition to the administrative controls imposed by the Radiation Protection Program for working with radioactive and potentially contaminated materials, the selected controls for this event are:

- Process vessel walls for those portions of the vessels enclosed by cooling jackets and Cs IX feed coolers tubes (~~SDC~~SS).

Evaluation (Acceptable): The reviewers concluded the new SS safety classification of the Cs IX feed cooler tubes was acceptable because it is consistent with the safety classification methodology of DOE-STD-3009. The classification was evaluated and accepted previously in Section C.1 of this SER.

3.4.1.7.1.1 Resin Dry Out and Overheating Due to Column Leak

Scenario Description
Loss of liquid from a loaded ion exchange column can lead to dry-out and overheating of the ion exchange resin media.

This event is prevented from occurring by ITS design and controls. The ion exchange columns are designed to minimize the likelihood of a leak. Also, an emergency elution system is credited to remove the heat load on ~~detection low liquid level in the column or on~~ indication of high resin bed temperature.

Other Represented Events
Two other identified mechanisms for resin bed dry out and overheating include a longterm plant or system shutdown that allows a column resin bed loaded with cesium to evaporate to dryness, and inadvertent blowdown of the column due to fault with the hydrogen mitigation system ~~pressurized purge air/level control system~~.

In the second mechanism, the nitrogen gas which inerts the hydrogen collected within the Cs IX trap and purge piping ~~purge air system sweeping hydrogen from the vapor space of the column~~ is postulated to develop a fault, which causes the pressurized ~~air~~ nitrogen gas to force the liquid out of the column. The ~~purge air~~hydrogen mitigation nitrogen system supply and exhaust regulating valves are connected to liquid level ~~transducers on the column~~sensors on the hydrogen collection piping. ~~When the liquid feed pump to the column shuts off, the purge air system supply valve throttles down (based on lowering liquid level indication) and the outlet valve opens appropriately to reduce vapor space pressure and to prevent blowdown.~~ Potential causes for an inadvertent blow-down of a column ~~high vapor space pressure in the column~~ include a failure of hydrogen mitigation system level sensors~~blocked exhaust path, an imbalance between the purge air supply and exhaust flows due to controller or PRV fault, and failure of the column liquid level detector~~. If ~~n~~ a blowdown scenario occurred, the screens on the outlet distributor to the column ensure that the resin is retained in the column. The liquid would be forced into or possibly through the two downstream operating columns.

An ~~I~~inadvertent blowdown results in the rapid evacuation of interstitial liquid from the column. Pour liquid will still have to be evaporated to allow resin overheating. For a stagnant condition in the blowdown column (high pressure, no flow), the evaporation time is similar to that calculated in the representative event (the blowdown time is insignificant in comparison). For a high flow condition (evacuation of liquid from transfer lines resulting in venting into the ~~vapor spaces of~~ the downstream column or upstream feed vessel), the ~~air~~ nitrogen flow would hasten pore liquid evaporation but would also serve to cool the bed.

~~As in the DBE, t~~The primary control strategy involves ~~activation of the emergency elution system~~ a level switch stopping the IX system pump, opening an additional vent path, and venting the nitrogen to a siphon break. ~~based on detection of low liquid level in the~~ The ~~level detector~~temperature indicator for activating emergency elution ~~shall be~~is separate from the level switches ~~detector~~ used to normally regulate level in the hydrogen collection piping~~column~~. ~~The ITS purge air system includes redundant exhaust paths to preclude blocked exhaust flow.~~

~~Given a blowdown condition occurs, high pressure in the column could compromise the ability to add the emergency elution chemicals. The ITS purge air control system will thus be designed to default to a low pressure state on low liquid level indication. This control minimizes resin exposure to oxidizing and evaporative effects of the purge airflow.~~

An additional control has been specified for this scenario that ensures valves on the LAW feed line and liquid outlet line close to isolate the column on detection of purging the hydrogen collection piping or column temperature indication ~~lowering liquid level in the column.~~ The response time of this control prevents uncovering of the bed. This control minimizes the likelihood of the initiating event similar to the robust vessel design for the DBE.

> Evaluation (Acceptable): The reviewers concluded the deletions in this section are acceptable because all dealt with the former level detection and purge air systems that were part of the obsolete hydrogen mitigation system. The reviewers agreed the additions are acceptable since they describe adequate controls and operation of the new hydrogen mitigation system for mitigating the potential to expose the resin to air or nitrogen through evaporation or inadvertent nitrogen system blowdown. The reviewers agreed the changes are acceptable because they reflect the ABAR's description of the

new hydrogen mitigation system and the associated emergency elution system, which are designed to “prevent a potential deflagration or detonation” and “prevent resin heatup to the point of thermal degradation or auto ignition” as described in the proposed modifications to the PSAR in Sections 4.4.16 and 4.4.17.

3.4.1.7.1.6 Requirements for Selected Control Strategy

The control strategies selected to prevent the occurrence of an overheat are:

- An emergency elution system, to remove the heat load on detection of ~~low liquid level~~high temperature in the column,
- A robust ion exchange column design, to minimize the likelihood of a leak

Emergency elution is initiated based on ~~either low liquid level indication in the column or~~ high resin bed temperature indication. ~~Low liquid level is indicative of draining of the resin bed interstitial liquid, which can lead to excessive self-heating of the resin media.~~ The temperature monitor provides direct indication of the overheating condition. Monitoring of liquid level in the hydrogen mitigation system and resin bed temperature provides ~~redundant, diverse detection of the initiating event.~~an indication of potential low liquid level in the column.

> Evaluation (Acceptable): The reviewers concluded the deletions in this section are acceptable because all dealt with the obsolete hydrogen mitigation and elution systems. The reviewers found the additions acceptable because they reflect the ABAR’s description of the new hydrogen mitigation system and the associated emergency elution system, which are designed to “prevent a potential deflagration or detonation” and “prevent resin heat up to the point of thermal degradation or auto ignition” as described in the proposed modifications to the PSAR in Sections 4.4.16 and 4.4.17.

Credited SSCs

1 Emergency elution system

As long as the resin bed remains submerged, overheating of the vented resin bed is not possible. An ITS emergency elution system is required to back up the normal elution system. When activated by ~~low level indication or~~ high temperature, the emergency elution system (1) initially resubmerges the resin bed with caustic solution, (2) rinses the resin bed with de-mineralized water, to minimize heat of dilution on addition of elution acid, (3) adds 0.5 M elution acid to remove the radioactive cesium from the resin media, and (4) reconditions the resin media back to caustic form for re-use or disposal. The column structure, ~~column level detection~~hydrogen mitigation system, resin bed temperature monitoring system, and the emergency elution system are designated as ITS, safety ~~design class~~ significant (~~SDC~~SS) equipment.

The vessels, piping, valves, and interlocks necessary to perform a controlled elution must all be designed and procured to ~~SDC~~ SS requirements. The ~~low level detection system and~~ temperature monitoring system provides ~~redundant and diverse~~the means to detect ~~conditions leading to~~ column overheating and to activate the emergency elution function. ~~Additionally, the emergency elution function must meet the single failure criterion.~~

The maximum response time has not yet been established. Conservative calculations in 24590-PTF-Z0C-W14T-00027, however, indicate that approximately 110 hours will be required to evaporate the pore liquid in the hottest part of the resin bed, after the bed has been drained, and to heat the resin bed up to 500 K, a conservatively estimated pyrolysis point. An appropriate safety factor should be applied in establishing the maximum response time to elute after continued detection of low liquid level in the ~~column~~hydrogen mitigation system. This response time ~~may~~ will allow for manual activation of emergency elution rather than automatic activation.

> Evaluation (Acceptable): The reviewers concluded the deletions in this section are acceptable because all dealt with the obsolete hydrogen mitigation system and its safety classification. The reviewers found the additions acceptable because they reflect the ABAR's description of the new hydrogen mitigation system and the associated emergency elution system, which are designed to "prevent a potential deflagration or detonation" and "prevent resin heat up to the point of thermal degradation or auto ignition" as described in the proposed modifications to the PSAR in Sections 4.4.16 and 4.4.17. The reviewers agreed with the changes in safety classifications since they were evaluated in Section C.1 of this SER and found acceptable.

Bounding Environmental Conditions

The ~~liquid level indication system in the column~~ IX temperature monitoring and any in-cell valves and interlocks must be designed to survive the radiation environment in the cell. Radiation hardening requirements will be determined based on the 150,000 Ci Cs-137 bed loading limit for the cell, plus appropriate accommodation for other sources in the cell.

1 Barriers/Credited Controls

In accordance with the defense in depth requirements~~,~~ two or more independent physical barriers ~~two independent ITS barriers~~ are provided:

- The ITS design of the ion exchange column
- ~~The emergency elution system~~ Cell concrete structure and C5 Ventilation system

The credited controls for these types of events:

- IX column confinement boundary
- Cell concrete structure and C5 Ventilation system
- Emergency Elution
- Column temperature monitoring indication
- Flooded column level detection Switch, LS-4 stops the IX system pump, opens an additional vent path, thus venting the column and collection piping. (This control is only for the prevention of nitrogen blow downs).

~~The first barrier~~One physical barrier is provided by the ITS design of the ion exchange column. The column is designed to high standards to minimize the likelihood of a leak that could induce resin media dry out. ~~The second barrier preventing the fire is provided by the emergency elution system.~~The second barrier consisting of the –C5 ventilation system and the cell walls provides secondary confinement of aerosols generated by the material spilled from the column (until detected) and while implementing emergency elution. The credited control consisting of emergency elution system is activated by ~~low liquid level indication in the column, or by~~ indication of high resin bed temperature. This emergency elution system ensures the resin is resubmerged and the radioactive cesium is removed before thermal degradation of the resin occurs should a leak develop in the column (i.e., should the first ITS barrier fail). The credited control for preventing nitrogen blow downs of the columns is the columns level detection switch, LS-4 stops the IX system pump, opens an additional vent path, thus venting the column and collection piping.

Required Modifications: For clarity and completeness, the fifth bullet in this section (i.e., *"Emergency Elution"*) must be deleted and replaced with *"Emergency elution system, including column temperature interlocks to automatically elute the columns at high temperatures"*.

For clarity and completeness, the sixth bullet in this section (i.e., "*Column temperature monitoring indication"*) must be deleted and replaced with *"Column temperature sensors"*.

For clarity and completeness, the following sentence, *"The credited control consisting of emergency elution system is activated by indication of high resin bed temperature."* must be deleted and replaced with, *"The credited control consisting of the emergency elution system is automatically activated by interlock with high resin bed temperature. As defense in depth, the emergency elution system also can be activated manually in response to rising temperatures and other potentially hazardous conditions."*

For clarity and completeness, the following paragraph must be added to the end of this section:

"LS-4 is one of several ITS controls for the emergency elution and hydrogen mitigation systems. Other key ITS controls include V-1, V-2, V-3, LS-1, and the column temperature sensors. LS-1, LS-4, and the column temperature sensors are interlocked with V-1, V-2, V-3, and other ITS valves to enable automatic operation of the IX column emergency elution and gas collection piping flush systems.

LS-4 is a level sensor that is interlocked on detection of gas at the level sensor to shut down the waste feed pump and open the V-1 and V-2 vent valves to prevent nitrogen blowdown of the IX columns and to vent a potential excessive accumulation of hydrogen in the gas collection piping to the vessel ventilation system. V-1 is an isolation valve located at the upper end of the collection piping that enables automated filling of the collection piping with inert nitrogen and the subsequent collection of gases generated within the IX columns when the valve is closed. The automated and manual (optional) opening of V-1 enable the safe venting of the collected gas, and the discharge of collection piping flush solution to a siphon break. V-2 is an isolation valve on a bypass line that enables automated emergency venting of the Cs IX column when the valve is open. V-3 is an isolation valve between the Cs IX column and the collection piping that enables automated venting of the column into the gas collection piping when the valve is open. The automated closing of V-3 prevents the discharge of highly radioactive pressurized waste into the collection piping when accumulated gas is being vented and flushed to the siphon break.

LS-1 is a level sensor that provides verification of venting of accumulated gas in the collection piping as well as the subsequent refilling of the collection system with nitrogen. LS-1 is interlocked with the hydrogen mitigation flush system to initiate flushing of the collection piping on detection of liquid at LS-1. As an added measure of protection, process *controls will be provided that limit the duration of time a column is out of service before it must be eluted manually or returned to service."*

Evaluation (Acceptable as modified): The reviewers concluded the deletions in this section are acceptable since all dealt with the obsolete hydrogen mitigation system. The reviewers found the additions (as modified) acceptable because they reflect the ABAR's description of the new hydrogen mitigation system and the associated emergency elution system, which are designed to "prevent a potential deflagration or detonation" and "prevent resin heat up to the point of thermal degradation or auto ignition." See the proposed modifications to the PSAR in Sections 4.4.16 and 4.4.17. The project document, "Design Basis Event – Overheating of Cesium Ion Exchange Media, Sheet 13", 24590-PTF-Z0C-W14T-00027 Rev C, also shows that at least 110 hours must pass after the resin has become exposed to air or nitrogen for the resin to reach the temperature required for auto ignition. This indicates that significant time exists for manual intervention, if needed.

Single Failure Criterion

The SRD requirements, application of the single failure criteria must be considered for SS controls. The C5 system, designated as SS for this event, will be designated as SC for other events and shown to meet the single failure criteria. Applicability of the single failure criteria to the remaining controls is discussed below.

For this event the IX column confinement boundary, based on a given loss of fluid in the column, caustic fluid from the elution tanks or demineralized water from CXP-VSL-00005 and SHR-VSL-00001 would be capable of preventing the IX column resin from becoming exposed and drying out. Hence, the confinement boundary does meet the single failure criteria.
For the Emergency Elution system, since the valves are located in an accessible area and operator intervention was determined satisfactory to account for potential valve failures.

As for the column temperature monitoring indication, based on the consequences of SL-2 to the public and the time required to heat the column the system was determined not to require single failure protection, as ample time is available for an operator response. In addition, as the temperature in the column rises, evaporation losses would also actuate the Hydrogen Purge controls. The level control "LS-3" instrument is for process purposes and is not required for properly performing the safety function. Level control LS-4 is classified as SS, and initiation of the LS-4 "Passive venting of the column" would instigate operation investigation of the event. Therefore, although not credited for this event, these components will however, reduce the demands placed on the temperature monitoring system. Thus for this event, the overall system provides adequate protections as any one of the controls could be removed and the event still would be prevented. In addition, the Single Failure criterion is not necessary for the temperature monitoring system.
~~A second stipulation for accidents with SL-1 consequences is that the single failure criterion should be applied to the ITS SSCs selected to mitigate the accident.~~
~~The selected barriers ensure the single failure criterion is met. A passive failure in the column is backed up by the emergency elution system, activated by low liquid level and/or high resin bed temperature. The low level and high temperature monitoring systems ensure redundant and~~

~~diverse detection of the initiating event. The emergency elution system (to be developed) will be provided with sufficient redundancy to ensure no single failure will defeat its safety function.~~

Required Modifications: For clarity and completeness, the following sentences and partial sentence must be deleted:

"For this event the IX column confinement boundary, based on a given loss of fluid in the column, caustic fluid from the elution tanks or demineralized water from CXP-VSL-00005 and SHR-VSL-00001 would be capable of preventing the IX column resin from becoming exposed and drying out. Hence, the confinement boundary does meet the single failure criteria. For the Emergency Elution system, since the valves are located in an accessible area and operator intervention was determined satisfactory to account for potential valve failures."

The deleted text must be replaced with the following:

"For this event, Resin Dry Out and Overheating Due to Column Leak, two normally closed emergency elution valves in series are located in an accessible area. Operators will have sufficient time to manually open them should they fail to open on a column high temperature indication. The column temperature monitoring system is classified SS and provides the operator the means to detect column overheating and to take appropriate action. Caustic fluid from the elution tanks or demineralized water from CXP-VSL-00005 and SHR-VSL-00001 would be capable of preventing the IX column resin from becoming exposed and drying. The single failure criterion for the remaining controls was considered unnecessary because the minimum 110 hours necessary to heat unwetted resin to the point of auto ignition allows sufficient time for manual intervention and correction."

Evaluation (Acceptable as modified): The reviewers concluded the deletions in this section are acceptable because all dealt with the obsolete hydrogen mitigation system. The reviewers concluded the additions (as modified) are acceptable because they reflect the ABAR's description of the new hydrogen mitigation system and the associated emergency elution system, which are designed to "prevent a potential deflagration or detonation" and "prevent resin heat up to the point of thermal degradation or auto ignition." See the proposed modifications to the PSAR in Sections 4.4.16 and 4.4.17. The project document, "Design Basis Event – Overheating of Cesium Ion Exchange Media, Sheet 13", 24590-PTF-Z0C-W14T-00027 Rev C, also shows that at least 110 hours must pass after the resin has become exposed to air or nitrogen for the resin to reach the temperature required for auto ignition. This indicates that significant time exists for manual intervention, if needed.

Additional Barriers

Additional barriers are required that prevent the occurrence of the event to meet the defense in depth principle. Based on the results of this analysis and a review of the events bounded by this event, the following defense in depth barriers have been identified:

- ~~SDC~~ Other mitigative systems are not required for thermal breakdown of the resin, as resin pyrolysis or burning is prevented with ~~SDC~~ SS controls. Resin overheating to the pyrolysis or autoignition point would be considered a beyond-design-basis event (BDBE). Should the BDBE occur, the primary release path is through the process vessel ventilation system (PVP/PVV). The particulate removal function of this system is ITS ~~(SDC)~~ for other accidents. This system ensures particulates generated in the fire are removed prior to discharge of process ventilation air to the environment. Should the system be overwhelmed by the soot release in the fire, venting to the cell air (via the column pressure relief device) and mitigation by the C5 system will occur. The secondary confinement function provided by the C5 ventilation system is designated ~~SDC~~ SC for other events in the Pretreatment facility. The PVP/PVV and C5 confinement systems provide defense in depth protection should the BDBE occur.

- Sump leak detection in the hot cell is designated commercial grade and is thus not credited in this analysis. This system, however, provides an additional means to detect the leak. The cell walls and C5 ventilation system provide secondary confinement of aerosols generated by the material spilled from the column (until detected) and while implementing emergency elution.

A 150,000 Ci Cs-137 bed loading limit has been defined as a TSR level administrative control to limit the radiolytic heat load in the bed, to limit radiolytic resin damage, and to limit radiolytic hydrogen generation. To stay within the safety envelope defined for this accident analysis and others (e.g., Cs ion exchange hydrogen deflagration), this loading limit cannot be exceeded. The analysis in 24590-PTF-Z0C-W14T-00027 uses the 150,000 Ci bed loading limit in determining the resin bed evaporation and heat-up times.

Required Modifications: For clarity, the following sentence in the second bulleted paragraph in this section must be deleted:

"The particulate removal function of this system is ITS for other accidents."

The deleted sentence must be replaced with the following:

"The particulate removal function of this system is SC for other accidents."

Evaluation (Acceptable as modified): The reviewers concluded the changes in safety classifications are acceptable because the associated CXP controls were evaluated and accepted in Section C.1 of this SER, and the SC designation for the C5 system and its particulate removal capability is consistent with the former SDC designation.

3.4.1.7.1.8 Conclusion

An emergency elution system is used to remove the source of decay heat in the ion exchange columns on detection ~~of low level or~~ high temperature in the column bed. The emergency elution system, ~~level monitoring system, and~~ temperature monitoring system are designated ITS and preclude the potential for resin dry out and overheating. In addition, the Cs ion exchange column is designated ITS. Its robust design minimizes the likelihood of a leak that could result in draining of the ion exchange bed, the initiating mechanism for the representative event. The column and ~~emergency elution~~C5 ventilation systems provide the two physical barriers to release required for SL-1 events. ~~The active portions of the ITS systems are redundant to ensure compliance with the single failure criterion.~~Resin dry out and self-heating to the pyrolysis or auto-ignition point, due to a column leak, is considered a BDBE, given the ITS control strategy.

Table 3A-9 summarizes the mitigated frequency and consequence results of this DBE analysis. Chapter 4 summarizes the attributes of the selected ITS SSCs and identifies candidate TSRs, and Table 3A-10 shows the post-accident environmental considerations for the design of the controls.

> Evaluation (Acceptable): The reviewers concluded the deletions in this section are acceptable since they either dealt with the obsolete hydrogen mitigation and emergency elution systems, or pertained to the former system classification, which required compliance with the single failure criterion. SS SSCs, including the new hydrogen mitigation and emergency elution systems, are not required to meet the single failure criterion. The reviewers concluded the additions are acceptable since they describe adequate ITS controls for the emergency elution system and the need for two physical barriers for mitigating releases with SL-1 consequences to external receptors.

3.4.1.7.2 Overconcentration of Elution Acid in the CNP or Standby Elution Systems Accident Scenario

1 Loss of Vacuum in the Evaporator

The preventative controls selected for this event include:

- Chemical monitor and trip on downcomer from rectifier (CNP-DISTC-00001) to the recovered acid vessel CNP-VSL-00004. Signal from the chemical monitor trips the IX feed/eluant transfer pump.
- Density indication in the recovered acid vessel.

~~Temperature monitor in the liquid phase of evaporator CNP-EVAP-00001. High temperature signal trips the IX column feed/eluant transfer pump suction and discharge valves.~~

The primary controls are the same as in the two scenarios discussed above. The overconcentration condition will be detected by the ~~safety design class~~additional protection class (~~SDC~~APC~~)~~ concentration monitor in the downcomer from the rectifier. The evaporator liquid boiling point will be elevated at higher acid concentrations. The overconcentration condition will thus also be detected via the ~~SDC temperature monitor in the evaporator.~~rectifier down comer concentration monitor/interlock and recovered acid vessel sampling.

2 Overcharging of the Recovered Acid Vessel with Greater than 3 M Acid from the Reagent Addition System

Depending on evaporator operating conditions, the acid concentration in the recovered acid vessel (CNP-VSL-00004) may fall below 0.5 M. Two molar acid is added via the reagent addition system to increase the acid concentration as necessary.

As in the evaporator overcharging scenario, it is possible for the charging acid to be inadequately diluted before transfer to the recovered acid vessel. The primary control for this event involves monitoring acid concentration in the 2 M supply line from BOF. The ~~SDC~~ APC concentration monitor trips isolation valves on detection of acid concentration ~~in excess of~~greater than 3 M.

3 Self-concentration of Recovered Acid Vessel Contents due to Evaporation

The primary control strategy for this scenario involves periodic sampling of the vessel contents. The sampling interval shall be set frequently enough to ensure self-concentration due to evaporation does not create a hazard. Sampling shall be required before initiating elution after any extended shutdown of the CNP system. The sampling requirement and interval shall be specified in TSR controls~~.~~. The over concentration condition will also be detected via the density indication of the recovered acid vessel.

4 Failure to Dilute Concentrated Acid Prior to Transfer to Standby Elution Tank

The primary control for this event involves monitoring acid concentration in the 0.5 M supply line from BOF. The ~~SDC~~ APC concentration monitors are interlocked to redundant isolation valves to prevent transfer of greater than 1 M acid from reaching the reagent head tank.

Required Modifications: For clarity and completeness, the following text in the first bulleted paragraph in this section must be deleted, *"Chemical monitor and trip on downcomer from rectifier (CNP-DISTC-00001) to the recovered acid vessel CNP-VSL-00004."* and replaced with, *"Nitric acid monitor on the downcomer from the rectifier (CNP-DISTC-00001) to the recovered acid vessel CNP-VSL-00004 and high-acid-concentration interlock (valve trip)."*

For clarity and completeness, the following text in the second bulleted paragraphs in this section must be deleted, *"Density indication in the recovered acid vessel."* and replaced with, *"Density monitor in the recovered acid vessel (alarm trip to signal operator intervention on high-density indication)."*

For clarity and completeness, the non-bulleted paragraph under "1. Loss of Vacuum in the Evaporator" must be deleted and replaced with the following:

"The Loss of Vacuum in the Evaporator condition will be detected by the APC acid concentration monitor in the downcomer from the rectifier. Higher acid concentrations will raise the evaporator liquid boiling point. The Loss of Vacuum in the Evaporator condition thus will also be detected via the rectifier downcomer concentration monitor/interlock and density indication in the recovered acid vessel."

Evaluation (Acceptable as modified): The reviewers concluded that eliminating the high-temperature interlock to trip the IX column feed/eluant feed transfer pump suction and discharge valves and adding an acid-density control to the recovered acid vessel would provide adequate controls to ensure acid concentration limits for protecting the resin are not exceeded in the case of a loss of vacuum in the acid evaporator. The safety classification changes are acceptable since they were all evaluated and accepted in Section C.1 of this SER.

<u>Credited SSCs</u>
The representative events and their credited SSCs are listed below:

1 Event: Loss of Vacuum in the Evaporator, Overconcentration in the Evaporator, and Overcharging of the Evaporator Vessel.
Credited SSCs: ~~Rectifier downcomer concentration monitoring system and evaporator temperature monitoring system.~~<u>Cell concrete structure and C5 ventilation system, IX column confinement boundary, flooded column level detection switch, LS-4, column temperature monitoring indication, and emergency elution.</u>

2 Event: Overcharging of the Recovered Acid Vessel
Credited SSCs: <u>Cell concrete structure and C5 ventilation system, IX column confinement boundary, flooded column level detection switch, LS-4, column temperature monitoring indication, and emergency elution.</u> ~~Concentration monitoring system on the 2 M nitric acid line in the reagent distribution system.~~

3 Event: Self-concentration of Recovered Acid Vessel Contents
Credited SSCs: <u>Cell concrete structure and C5 ventilation system, IX column confinement boundary, flooded column level detection switch, LS-4, column temperature monitoring indication, and emergency elution.</u>~~Periodic sampling of the recovered acid vessel contents.~~

4 Event: Evaporator Overflow into Recovered Acid Vessel
Credited SSCs: <u>Cell concrete structure and C5 ventilation system, IX column confinement boundary, flooded column level detection switch, LS-4, column temperature monitoring indication, and emergency elution.</u>~~Evaporator breakpot and overflow line design.~~

5 Event: Failure to Dilute Concentrated Acid Prior to Transfer to Standby Elution Tank
Credited SSCs: <u>Cell concrete structure and C5 ventilation system, IX column confinement boundary, flooded column level detection switch, LS-4, column temperature monitoring indication, and emergency elution.</u>~~Concentration monitoring system on the 0.5 M nitric acid line to the reagent head tank.~~

6 Event: Self-concentration in the 0.5 M Nitric Acid Head Tank
Credited SSCs: <u>Cell concrete structure and C5 ventilation system, IX column confinement boundary, flooded column level detection switch, LS-4, column temperature monitoring indication, and emergency elution.</u>~~Periodic sampling of the 0.5 M nitric acid head tank contents, periodically monitoring the head tank level using the tank level instrumentation.~~

<u>Required Modifications:</u> For clarity and completeness, the following text in each of the paragraphs numbered 1 through 6 above must be deleted: *"column temperature monitoring indication, and emergency elution."* The deleted text must be replaced with *"emergency elution system, column temperature sensors, and the temperature sensor interlocks to the emergency elution system."*

<u>Evaluation (Acceptable as modified):</u> The reviewers concluded the deletions in this section are acceptable since all dealt with controls for preventing high acid conditions in the IX columns when using the obsolete hydrogen mitigation and emergency elution systems. The reviewers concluded the additions (as modified) are acceptable since they identify the new controls for preventing use of over-concentrated acid in the IX columns based on the effectiveness of the new hydrogen mitigation and emergency elution systems as described in the revised Sections 4.4.16 and 4.4.17 of the PSAR (per ABAR-24590-WTP-SE-ENS-03-1144), and the new safety classification system as evaluated in Section C.1 of this SER.

The functional requirements for the ITS barriers credited in the DBE analysis are discussed below.

1 Cell concrete structure and C5 ventilation system~~Rectifier Downcomer Concentration and Evaporator Temperature Monitoring Systems~~

These two sets of controls provide redundant, diverse prevention of the accident. The cell walls act in combination with the C5 exhaust fans to ensure aerosols generated in these events remain confined to the C5 cell air, and this contaminated air escapes out-cell only through the HEPA filtered exhaust path provided by the C5 ventilation system. The cell walls passively maintain this function, as discussed above, provided confinement velocity is maintained by the C5 ventilation system across all potential in-leakage paths through the walls.

~~These two sets of controls provide redundant, diverse prevention of the accident. The rectifier downcomer concentration monitoring system is required to signal and close the eluant feed pump isolation valves on detection of 3 M (or higher strength) nitric acid. It is anticipated that the chemical monitor in the downcomer will consist of either a conductivity probe or density meter. The evaporator temperature monitoring system is required to trip isolation valves on the transfer line from the recovered acid vessel to the cesium IX column. The setpoint for this system shall be defined during detailed design. The temperature setpoint shall be set based on vapor/liquid equilibrium curves for the water/nitric acid/~~$\cancel{CsNO_3}$ ~~mixture in the evaporator. The temperature setpoint shall be set at a value that ensures less than 3 M in the condensed evaporator overheads, with appropriate safety margin. The evaporator temperature monitor will be set based on vapor/liquid equilibrium curves at a value that ensures condensed overheads are less than 3 M, with appropriate safety margin. The feed pump is instrumented to shutdown under deadhead conditions to prevent pump damage.~~

2 IX column confinement boundary~~Concentration Monitoring System on the 2 M Nitric Acid Line in the Reagent Distribution System~~

The ion exchange column is designed robustly to minimize the likelihood of a leak by maintaining confinement boundary during and after the representative events and their credited SSCs as listed above.

~~The concentration monitoring function on the 2 M nitric acid line in the reagent distribution system is required to isolate feed on detection of acid concentration 3 M or greater. Redundant concentration monitors, interlocks, and isolation valves are required to meet the single failure criterion.~~

3 ~~Periodic Sampling of the Recovered Acid Vessel~~Emergency elution system

When activated by one of the following: high temperature within the column, Cs IX hydrogen mitigation level switch LS-4, or operator initiated. The emergency elution system (1) initially resubmerges the resin bed with caustic solution, (2) rinses the resin bed with demineralized water, to minimize heat of dilution on addition of elution acid, (3) adds 0.5 M elution acid to remove the radioactive cesium from the resin media, and (4) reconditions the resin media back to caustic form for re-use or disposal. The column structure, hydrogen mitigation level detection system, resin bed temperature monitoring system, and the emergency elution system are designated safety significant (SS) equipment.

The vessels, piping, valves, and interlocks necessary to perform a controlled elution must all be designed to SS requirements. The hydrogen mitigation level detection system and temperature monitoring system provide redundant and diverse means to detect conditions leading to column overheating and to activate the emergency elution function.

~~The Recovered Acid Vessel (CNL-VSL-00004) is required to be periodically sampled to verify proper acid concentration. The sampling interval shall be set based on the calculated maximum evaporation rate for the vessel and shall occur frequent enough to preclude self-concentration to acid molarities approaching 3 M. For any system shutdown longer than the sampling interval, sampling to verify an acceptable acid concentration shall be performed before eluting the column.~~

~~4 Evaporator Breakpot and Overflow Line Design~~
~~The design features which prevent evaporator overflow into the rectifier must be protected by configuration control. The overflow on the evaporator breakpot (CNP-BRKPT-0002) is required to be sized large enough to accommodate the maximum flowrate of acid from BOF, combined with recycled elute from the CXP system, without causing liquid to back up into the evaporator rectifier (CNP-DISTC-00001). If the wash rings are inadvertently activated while the evaporator is under vacuum, the volume of water required to fill in the vapor space of the evaporator and to flood the rectifier is expected to dilute the acid concentration to below 3 M before it overflows through the rectifier into the recovered acid vessel.~~

~~5 Concentration Monitoring System on the 0.5 M Nitric Acid Line to the Reagent Head Tank~~
~~The concentration monitoring function on the 0.5 M nitric acid line to the reagent head tank NAR-TK-00007 is required to isolate feed on detection of acid concentration in excess of the setpoint. The setpoint shall be set no higher than 3 M. Redundant concentration monitors, interlocks, and isolation valves are required to meet the single failure criterion.~~

~~6 Periodic sampling of the 0.5 M Nitric Acid Head Tank~~
~~The 0.5 M nitric acid head tank NAR-TK-00007 shall be periodically sampled to verify proper acid concentration.~~

~~7 ITS 0.5 M Nitric Acid Head Tank Level Instrumentation~~
~~The level indication provides a means to periodically verify that sufficient acid is available for emergency elution.~~

~~8 C5 Ventilation Air System~~
~~The 5 M testing results, upon which the 3 M setpoint was established, showed an exotherm above 50 °C. The analysis assumes elution is not performed with acid exceeding this temperature. SDC temperature control in the evaporator and cooling provided by the (SDC) C5 cell ventilation air is credited with preventing elution with acid greater than 50 °C in temperature.~~

Required Modifications: For clarity and correctness, the first paragraph in this section must be deleted and replaced with the following:

"Cell concrete structure and C5 ventilation system
This control prevents the accident. The C5 System meets the single failure criterion. The cell walls act in combination with the C5 exhaust fans to ensure aerosols generated in these events remain confined to the C5 cell air, and this contaminated air escapes out-cell only through the HEPA-filtered exhaust path provided by the C5 ventilation system. The cell walls maintain this function, as discussed above, provided the air-confinement velocity is

maintained by the Safety Class C5 ventilation system across all potential in-leakage paths through the walls."

For clarity and correctness, the second paragraph in this section must be deleted and replaced with the following:

"IX column confinement boundary
The ion exchange column and the associated credited SSCs are designed to maintain the confinement boundary during and after the representative events as listed above."

For clarity and correctness, the final paragraph in this section must be deleted and replaced with the following:

"The vessels, piping, valves, and interlocks necessary to perform elution must all be designed to SS requirements. The hydrogen mitigation level detection system and temperature monitoring system provide diverse means to detect conditions leading to column overheating and to activate the emergency elution function."

Evaluation (Acceptable as modified): The reviewers concluded the deletions in this section are acceptable since all dealt with controls for preventing high acid conditions in the IX columns when using the obsolete hydrogen mitigation and emergency elution systems under the former safety classification system. The reviewers agreed with the additions (as modified) since they identify new controls for preventing use of and mitigating the effects of over-concentrated acid in the IX columns based on the new hydrogen mitigation and emergency elution systems as described in the revised Sections 4.4.16 and 4.4.17 of the PSAR, and the new safety classification system as evaluated in Section C.1 of this SER.

Bounding Environmental Conditions

The ~~evaporator temperature monitor~~Cs IX column confinement boundary must be designed to withstand the high radiation associated with the cesium concentrate in the evaporator, and the corrosive environment associated with up to 8 M nitric acid at boiling temperatures. The ~~concentration monitors~~column temperature indicators within the Cs IX column ~~on the 0.5 M and 2 M acid lines from BOF and in the rectifier downcomer~~ must be designed to withstand the corrosive environment of up to 12 M nitric acid, as accidents are postulated that could result in 12 M acid in these areas. The isolation valves on the ~~0.5 M and 2 M feed~~ emergency elution lines from ~~BOF and on the eluant feed line~~ to the columns must also be designed to ensure operability in 12 M acid. Interlock wiring and all hydrogen mitigation level sensors and column temperature indicators must~~routed in-cell must~~ be designed to withstand the radiation fields expected in-cell.

Required Modifications: For clarity and correctness, the second and final sentences in the above paragraph must be deleted and replaced with the following:

(Second sentence) *"The column temperature sensors (elements) within the Cs IX column must be designed to withstand the corrosive environment of up to 12 M nitric acid, as accidents are postulated that could result in 12 M acid in the columns."*

(Final sentence) *"Interlock wiring and all hydrogen mitigation level sensors and column temperature sensors must be designed to withstand the radiation fields expected."*

Evaluation (Acceptable as modified): The reviewers concluded the deletions in this section are acceptable since all dealt with the obsolete acid control, hydrogen mitigation, and emergency elution systems. The reviewers concluded the additions (as modified) are acceptable since all adequately address the controls and operation of the new hydrogen mitigation and emergency elution systems. The reviewers found the additions acceptable because they reflect the ABAR's description of the new hydrogen mitigation system and the associated emergency elution system. These systems are designed to "prevent a potential deflagration or detonation" and "prevent resin heat up to the point of thermal degradation or auto ignition" as described in the proposed modifications to the PSAR in Sections 4.4.16 and 4.4.17.

Defense in Depth Requirements
The events and their defense in depth controls are identified below:

1 Event: Loss of Vacuum in the Evaporator/ Overconcentration in the Evaporator / Overcharging of the Evaporator Vessel / Evaporator Overflow into Recovered Acid Vessel
Defense in Depth Controls: These two sets of controls provide redundant, diverse prevention of the accident. The rectifier down comer (RDC) concentration monitoring system is required to signal and close the eluant feed pump isolation valves on detection of >3 M (or higher strength) nitric acid. It is anticipated that the chemical monitor in the down comer will consist of either a conductivity probe or density meter. The recovered acid vessel sampling is ensures that the RDC has performed its function and that the acid is not self concentrating or evaporating within the recovered acid vessel.
~~The evaporator is instrumented to detect loss of vacuum and shutdown the steam supply to the reboiler. The recovered acid vessel contains density and temperature indication that provide additional means to detect high concentration acid in the vessel prior to or during an elution.~~

~~2 Event: Overconcentration in the Evaporator~~
~~Defense in Depth Controls: Defense in depth protection is provided by density monitors in both the evaporator and recovered acid vessel. The liquid level in the evaporator is also monitored since the water loss will result in a drop in liquid level in the evaporator.~~

~~3 Event: Overcharging of the Evaporator Vessel~~
~~Defense in Depth Controls: Defense in depth protection is provided by density monitors in both the evaporator and recovered acid vessel. Additional controls at the dilution station in BOF ensure the likelihood of inadequate acid dilution is minimized~~

2 Event: Overcharging of the Recovered Acid Vessel
These two sets of controls provide redundant, diverse prevention of the accident. The make up concentration monitoring system is required to signal and close two isolation valves on detection of >3 M (or higher strength) nitric acid. It is anticipated that the chemical monitor on the BOF supply line will consist of either a conductivity probe or density meter. The recovered acid vessel sampling is ensures that the RDC has performed its function and that the acid is not self concentrating or evaporating within the recovered acid vessel.

~~Defense in Depth Controls: The density monitor in the recovered acid vessel provides an additional means to detect the overconcentration condition in real time. Additional controls at the dilution station in BOF ensure the likelihood of inadequate acid dilution is minimized.~~

3 Event: Self-concentration of Recovered Acid Vessel Contents
~~Defense in Depth Controls:~~ The recovered acid vessel sampling ensures that the acid is not self concentrating or evaporating within the recovered acid vessel. ~~The density monitor and level gauge in the recovered acid vessel provides additional means to detect the overconcentration condition.~~
~~Event: Evaporator Overflow into Recovered Acid Vessel~~
~~Defense in Depth Controls: In the event the overflowing acid solution remains above the 3 M setpoint, the SDC concentration monitor/pump isolation valves interlock in the downcomer will prevent elution of the column with concentrated acid.~~

4 Event: Failure to Dilute Concentrated Acid Prior to Transfer to Standby Elution Tank
The make up concentration monitoring system is required to signal and close two isolation valves on detection of >3 M (or higher strength) nitric acid. It is anticipated that the chemical monitor on the BOF supply line will consist of either a conductivity probe or density meter.~~Defense in Depth Controls: A concentration monitor in the standby elution tank will alarm when the acid concentration exceeds the setpoint value.~~

5 Event: Self-concentration in the Standby Elution Tank
The density monitor and level gauge in the recovered acid vessel provides additional means to detect the overconcentration condition.
~~Defense in Depth Controls: A concentration monitor in the standby elution tank will alarm when the acid concentration exceeds the setpoint value.~~

Required Modifications: For clarity and correctness, the paragraphs under the first and second "Events" must be deleted and each replaced with the following:

"Defense in Depth Controls: These controls provide diverse prevention of the accident. The rectifier downcomer (RDC) concentration monitoring system is required to signal and close the eluant feed pump isolation valves on detection of 3 M (or higher strength) nitric acid. It is anticipated that the chemical monitor in the RDC will consist of a conductivity probe. Recovered acid vessel sampling ensures that the RDC concentration monitoring system has performed its function and that the acid is not self-concentrating or evaporating within the recovered acid vessel."

Evaluation (Acceptable as modified): The reviewers concluded the deletions in this section are acceptable since all dealt with controls associated with the obsolete acid control systems. The reviewers agreed with the additions (as modified) since all address defense-in-depth controls that augment the credited controls of the new hydrogen mitigation and emergency elution systems that prevent the unacceptable consequences (resin degradation and fire) of acid reactions in the IX columns. The reviewers found the additions acceptable because they reflect the ABAR's description of the new hydrogen mitigation system and associated emergency elution system. These systems are designed to "prevent a potential deflagration or detonation" and "prevent resin heat up to the point of thermal degradation or auto ignition' as stated in the proposed modifications to the PSAR in Sections 4.4.16 and 4.4.17.

3.4.1.7.2.8 Conclusion

~~SDC~~ SS and APC controls are provided to prevent concentrated acid from being used to elute the column from either the CNP system or standby elution tank NAR-TK-00007. ~~The preventative controls are redundant and diverse and meet the single failure criterion.~~ A runaway reaction event in the column is considered to be beyond design basis, given the preventative controls. The hot cell structure and C5 ventilation system provide defense in depth protection.

Required Modifications: For clarity and correctness, the following sentence must be deleted: *"A runaway reaction event in the column is considered to be beyond design basis, given the preventative controls."*

Evaluation (Acceptable as modified): The reviewers concluded the deletions in this section are acceptable. The first deletion dealt with controls for preventing high acid conditions in the IX columns when using the obsolete hydrogen mitigation and emergency elution systems under the former safety classification system. The required deletion dealt with an event that is a design basis event in the PSAR (See CSD-PCNP/N0008 in Appendix A) for which a case has not been made that the mitigated event is beyond design basis. However, given the controls, the event is adequately mitigated. The reviewers agreed with the safety classification changes since they are consistent with the new safety classification system as evaluated in Section C.1 of the SER.

3.4.1.8 Hydrogen Explosions

Design Inputs

Design data used in this analysis are contained in 24590-PTF-Z0C-H01T-00002, *Design Basis Event- PTF Hydrogen Calculations*; ~~24590-PTF-Z0C-W14T-00026, *Design Basis Event - Hydrogen Accumulation in Cesium Ion Exchange Column Gas Separation Vessel*; and~~ 24590-PTF-Z0C-W14T-00033, *Design Basis Event - Hydrogen from Jumper Leaks in Pretreatment Cells*.

Evaluation (Acceptable): The reviewers concluded the deletion in this section is acceptable since it referred to a calculation involving the obsolete hydrogen mitigation system.

3.4.1.8.4 Ion Exchange Column Explosion

~~Hydrogen can accumulate in a cesium ion exchange (Cs IX) column, resulting in a potential deflagration or detonation.~~ Hydrogen is generated in the cesium ion exchange columns due to radiolytic degradation of the organic IX resin media and LAW solution contained within the columns. Chemical reactions between soluble organics and aluminum in the LAW waste can also produce hydrogen (thermolysis mechanism). There is a concern that hydrogen gas bubbles will ~~can rise through the resin bed and~~ accumulate ~~in the vapor space of the column.~~ This problem is exacerbated during low or no flow conditions in the column (e.g., due to loss of power, failure of the liquid feed pump, etc.), resulting as dissolved and entrained hydrogen will not be swept out in the liquid stream. Accumulated hydrogen in the ~~vapor space of the~~ column collection system piping can be postulated to be ignited by static discharge, electrical discharge from instruments, or arcing from a lighting strike grounding through a path that includes the IX column.

Whenever a specified amount of gas is collected within the hydrogen mitigation system (as indicated by level switches), at the end of every Cs IX column operation mode, the collection piping is flushed with weak caustic and the flush liquid and gas are vented to a siphon break. The siphon-break separates the gas from liquid, directs liquid to be recycled via the PWD system, and vents the gas to the PVV system. The purge air supplied to the siphon break is required to provide a gas flow 100 times the maximum gas generation rate from the column. In addition, the siphon-break headspace volume is sized to dilute excess hydrogen released from the hydrogen mitigation system to less than the lower flammability limit during off-normal events. ~~To ensure that unacceptable releases do not occur due to hydrogen deflagrations or detonations, the WTP has committed to providing purging to dilute hydrogen concentrations in vessels to below 25 % of the LFL. This control philosophy applies to all vessels with estimated times to flammable less than 3000 h. In the case of cesium ion exchange, ITS pressurized air provides purging. This system prevents flammable gas accumulation and precludes hydrogen burns.~~

Required Modifications: For clarity and correctness, the first paragraph in this section must be deleted and replaced with the following:

"Hydrogen can accumulate in a cesium ion exchange (Cs IX) column, resulting in a potential deflagration or detonation. Hydrogen is generated in the cesium ion exchange columns due to the radiolytic degradation of the organic IX resin media and LAW solution contained within the columns. Chemical reactions between soluble organics and aluminum in the LAW waste can also produce hydrogen (thermolysis mechanism). There is a concern that hydrogen gas bubbles will rise through the resin bed and accumulate. This problem is exacerbated during low or no flow conditions in the column (e.g., due to loss of power, failure of the liquid feed pump, etc.), because dissolved and entrained hydrogen will not be swept out in the liquid stream. Accumulated hydrogen in the column collection system piping can be postulated to be ignited by static discharge, electrical discharge from instruments, or arcing from lightning-strike grounding through a path that includes the IX column."

Evaluation (Conditionally acceptable as modified): The reviewers disagreed with deleting the statement that "hydrogen can accumulate" since the revised hydrogen mitigation system includes a credited control (LS-4) that specifically prevents excess hydrogen from accumulating in the IX column. Deletion of reference to hydrogen bubbles rising through the resin also is unacceptable because that phenomenon appears likely under low or no flow conditions in the column when the column is loaded with Cs-137. Deletion of the term "vapor space" is acceptable since the new hydrogen mitigation system is designed to prevent the formation of vapor space within the column. Deletion of the last sentence is acceptable as it relates to the obsolete hydrogen mitigation system. The reviewers concluded the additions (as modified) are acceptable since they identify details of the new controls of the new hydrogen mitigation system, which is designed to "prevent a potential deflagration or detonation" as described in the revised Section 4.4.16 of the PSAR.

The reviewers were unable to verify the adequacy of the Contractor's assumed sudden release of one liter of hydrogen upon loss of power, failure of the liquid feed pump, or other condition that causes flow to cease. The Contractor reported that football-sized releases of gas were observed in testing a laboratory-scale column, often during elution (see the response to RT-31 in Attachment 1 to this SER). The volume of a football is about one liter. No attempt has been made to scale the observed gas release volume to the volume expected in the larger full-scale IX column. The 1-liter release assumption serves as a primary basis for evaluating the effectiveness of the hydrogen mitigation system design. See Condition of Acceptance No. 3 in Section D of this SER, which requires an evaluation the bounding gas bubble conditions and associated hazards. Moreover, the statement that purge air supplied to the siphon break is required to provide a gas flow 100 times the maximum gas generation rate from the column does not necessarily prevent the formation of a momentary explosive gas mixture in the siphon break. This issue is explained in the following scenario:

If gas containing 67% hydrogen (the assumed maximum hydrogen level) is being generated in the column and the nitrogen volume is nominally 4.5 liters and the nominal volume of IX column gas collected is 1.0 liter (at the L3 purge trip level), the sudden release of a bubble containing an additional one liter of gas will result in a nitrogen-inerted hydrogen concentration of greater than 20% in the inerting chamber. When this gas is released into the siphon break, it will depressurize and expand by a factor of about 5X, resulting in the release of about 33 liters of gas containing 20% hydrogen into the siphon break. Because the siphon's air purge rate of 100 times the maximum gas generation rate from the column is about the same as the human breathing rate, it will have little immediate effect in diluting the 20% hydrogen stream that will be injected into the air-filled siphon break at a rate much higher than the human breathing rate. Some mixing of the 20% hydrogen stream and the air (21% oxygen) in the siphon break will occur during the injection, likely resulting in layers of gas that are above the 4% LFL for hydrogen and the Contractor's 6% limit for oxygen.

If, as the Contractor recently indicated in its presentation to the Defense Nuclear Facilities Safety Board (DNFSB) on September 2, 2004, the nitrogen volume will be increased to 10.15 liters and the volume of IX column gas collected reduced to 0.7 liter, the sudden release of an additional one liter of gas at 67% hydrogen would result in a nitrogen-inerted hydrogen concentration of nearly 10% in the inerting chamber. Approximately 60 liters of this gas at 10% hydrogen would be injected into the siphon break at a high rate. Although the hazard is reduced in this scenario, the limited mixing of the injected gas stream and siphon-break air that will occur during the injection may still result in flammable compositions. See Condition of Acceptance No. 3 in Section D of this SER, which requires the Contractor to demonstrate the safety of the proposed method of releasing "inerted" gas that may contain hydrogen above the LFL into the air-filled hydrogen mitigation siphon break.

3.4.1.8.4.1 Accident Scenario

Hydrogen produced in the Cs IX column will dissolve to a large extent in the LAW solution. Soluble hydrogen and any hydrogen bubbles produced due to solution saturation would normally be expected to be entrained and swept out of the column in the flowing liquid stream. A loss of flow situation is the likely initiator for substantial hydrogen release into the vapor space of the column or piping. As discussed in 24590-PTF-Z0C-W14T-00026, there is concern that the velocity of rising hydrogen bubble may exceed the superficial velocity of liquid downflow through the column. In this case, hydrogen would accumulate in the column, where it would be collected in the nitrogen inerting collection piping. For flammable gas to exceed the nitrogen inerting gas volume within the column's collection piping, a loss of the level control would be required. ~~accumulate in the vapor space, a concurrent loss of the normal purge airflow through the column vapor space would be also required. A loss of power scenario can be postulated to result in common-cause shutdown of both the liquid feed pumps to the column and the normal purge air supply.~~

The methodology and potential unmitigated consequences of hydrogen burns/explosions in the Cs IX system are summarized in 24590-PTF-Z0C-W14T-00026. Receptor dose consequences were estimated for ~~vapor space~~ hydrogen gas concentrations ranging from 4 % (LFL) to 30 % (near stoichiometric concentration in air).

In the mitigated event, accumulation of hydrogen to flammable levels in the ~~vapor space of the~~ column's collection piping ~~-~~is precluded by design of the hydrogen mitigation system which consists of collection piping, valves, level sensors, and nitrogen inerting gas. The purge air supply line to the ~~column~~ siphon break is instrumented to detect loss of normal purge ~~air flow~~airflow and valve-in the ITS backup purge air supply. This is sized to maintain the hydrogen concentration in the vapor space of the siphon-break at 1 vol % or less under worst-case conditions (i.e., maximum column loading and operating temperature). Crediting ITS controls, a hydrogen burn in a Cs IX column is considered beyond design basis.

Required Modifications: For clarity and completeness, the following text must be added to the end of the first paragraph:

"A loss of level control would require failure of the credited LS-4 level sensor. This sensor employs elements that require no contact with the slightly radioactive, slightly caustic solution in the hydrogen collection piping. This no-contact feature and low solution corrosivity are expected to result in high sensor reliability. The functionality of the SS LS-4 sensor (which is not required to meet the single failure criterion in accordance with the revised safety criteria defined in the SRD) will be verified."

For additional clarity, the last sentence in this section must be deleted since a hydrogen burn in a column is identified as a hazard in the PSAR and since issues concerning hydrogen accumulations are unresolved.

Evaluation (Conditionally acceptable as modified): The reviewers concluded the deletions were acceptable since they pertained to the obsolete hydrogen mitigation system. The last sentence in this section also must be deleted since a hydrogen burn in a column is identified as a hazard in CSD-PCXP/N0020 in Appendix A of the PSAR and since issues concerning hydrogen accumulations are unresolved as indicated in Section D of this SER and elsewhere. The reviewers concluded the additions (with the required addition on the failure of level control) since they pertained to the design of the new hydrogen mitigation system. However, the statement that purge air is supplied to the siphon break to maintain the hydrogen concentration in the vapor space of the siphon-break at 1 vol % or less under worst-case conditions (i.e., maximum column loading and operating temperature) does not necessarily preclude a momentary explosive gas mixture when a large, off-normal hydrogen bubble is suddenly released through the hydrogen mitigation system into the siphon break, or if hydrogen in concentrations above the lower flammability limit (LFL) is released normally through the hydrogen mitigation system into the siphon break at a rate higher than can be diluted by the purge air. As noted in the reviewers' evaluation of the changes in the section above, the reviewers were not able to verify the basis and adequacy of the Contractor's assumed sudden release of one liter of hydrogen in the IX column. See Condition of Acceptance No. 3 under Section D of this SER, which requires improved bases for the release and accumulation of hydrogen-containing gases.

3.4.1.8.4.6 Requirements for Selected Control Strategy

Selected Control Strategy

Given the potential severity of a hydrogen burn in the cesium ion exchange ~~vapor space~~column, the potential damage to the CXP system, and the expense of recovering from the event, a preventative control strategy was selected. Consistent with other vessels in the facility with a significant hydrogen generation rate, the preventative control involves purging of the vapor space of the ~~vessel~~ siphon break. ~~. Pressurized air~~ Liquid level sensors are~~is~~ used to maintain proper ~~column~~ liquid level and nitrogen volume within the hydrogen collection/inerting piping. The supply and exhaust valves for this system will be designed to ensure a minimum purge air flowrate, under all operating conditions, sufficient to maintain the vapor space of the ~~cesium ion exchange column~~ siphon break at or below 1 vol % hydrogen. The 1 % limit corresponds to 25 % of the LFL for hydrogen. The normal purge air supply will be backed up by an ITS purge air supply meeting the single failure criterion. On detection of loss of normal airflow, the backup purge air system is activated. ~~The backup purge air system will be connected to ITS emergency power.~~

Given the ITS design of the IX column hydrogen mitigation system, a hydrogen burn or explosion in the ~~vapor space of the~~ column is considered to be adequately prevented. Deterministically, a flammable gas burn in an IX column is considered to be beyond design basis.

The cesium ion exchange columns are located in the hot cell, which is ventilated by the ~~SDC~~ SC C5 system. Secondary confinement provided by the cell walls and C5 system constitute conventional defense in depth protection for the hydrogen burn.

Required Modifications: For correctness, the following sentence must be deleted since a hydrogen burn in a column is identified as a hazard in the PSAR:

"Deterministically, a flammable gas burn in an IX column is considered to be beyond design basis."

Evaluation (Acceptable as modified): The reviewers concluded the deletions in this section are acceptable since all dealt with the obsolete hydrogen mitigation system. The second sentence in the second paragraph in this section also must be deleted since a hydrogen burn in a column is identified as a hazard in CSD-PCXP/N0020 in Appendix A of the PSAR and since the preventative systems do not generally meet the single failure criterion. The reviewers concluded the additions are acceptable since they address the controls and operation of the new hydrogen mitigation system system, which the reviewers found acceptable for the described safety application.

Credited SSCs

The IX columns confinement boundary is responsible for confining the following event: (1) Should a highly loaded column lose liquid or dry out over an extended time frame, the resin media may overheat. (2) Heat transfer in the resin bed of a dry column will be compromised due to the presence of insulating "dead" air in the void spaces between the resin particles. (3) If the centerline temperature of the resin is elevated, it is possible that the organic resin will thermally degrade (pyrolyze) or autoignite.

The Cs IX hydrogen mitigation system collects the gases generated in the IX columns. This gas is generated by radiolytic degradation of water and the organic materials in the column; as well as, thermolytic degradation of organic materials within the columns. During normal operation, this gas (hydrogen, oxygen, carbon dioxide, and various other gases) travels up the flooded column and connecting piping to the collection-piping bulge. The collection piping in the bulge contains a minimum volume of nitrogen such that all gas collected is inert.

The purge air system is required to provide sufficient gas flow to ensure a hydrogen gas concentration in the ~~vessel headspace~~ siphon break is less than 1 vol % (25 % of the LFL). The bounding hydrogen generation rate shall be determined. The volumetric flow rates through the normal and backup purge air systems shall be set at 100 times the maximum calculated hydrogen generation rate, correcting for column operating pressure and temperature, to maintain a steady-state hydrogen concentration less than 1 vol %. The regulated valves in the purge air supply and exhaust shall be designed to ensure the minimum required flowrate during the column loading and regeneration operating modes.

Required Modifications: For clarity, the first paragraph under "Credited SSCs" in this section must be deleted:

Evaluation (Acceptable as modified): The reviewers concluded the "vessel headspace" deletion in this section is acceptable since it dealt with the obsolete hydrogen mitigation system. The first paragraph in this section also must be deleted because it pertains to the resin overheating hazard, not the hydrogen explosion hazard evaluated in Section 3.4.1.8 of the PSAR. The overheating event is mitigated by the emergency elution system, not the hydrogen mitigation system. The reviewers concluded the additions are acceptable since they address the operation of the new hydrogen mitigation system, which the reviewers found acceptable because it is designed to "prevent a potential deflagration or detonation" as described in the revised Section 4.4.16 of the PSAR.

Bounding Environmental Conditions

The hardware used to detect loss of normal purge airflow and to valve in backup purge airflow must be designed to withstand the radiation fields expected in the ~~bulge~~ siphon-break containing the equipment. The level control instrumentation in the ~~column~~ bulge, controls the purge air regulation valves. To ensure proper operation of these valves the level instrumentation should be designed to withstand the intense radiation fields experienced in the column in-cell. A maximum loading limit of 150,000 Ci of Cs-137 was established for the lead ion exchange column. Other sources of radiation in the cell shall be considered in demonstrating adequate radiation resistance.

Required Modifications: For clarity and correctness, the following sentence must be deleted:

"To ensure proper operation of these valves the level instrumentation should be designed to withstand the intense radiation fields experienced in the column in-cell."

The deleted sentence must be replaced with the following:

"To ensure proper operation of these valves, the level instrumentation should be designed to withstand the radiation fields expected under normal and off-normal conditions."

Evaluation (Acceptable as modified): The reviewers concluded the deletions in this section are acceptable since all dealt with the obsolete hydrogen mitigation system. The reviewers conclude the additions (as modified) are acceptable since they adequately describe the controls and operation of the new hydrogen mitigation system. The ORP-required modification accounts for expected normal and off-normal conditions.

Defense in Depth Requirements

As discussed previously, the unmitigated consequences of a hydrogen explosion in the Cs IX column ~~gas separation vessel has~~has been determined to have potential SL-2 consequences, to the maximally exposed co-located worker. The defense in depth requirements for SSCs to prevent or mitigate accidents states that two independent physical barriers to release should be provided for SL-2 events. ~~There is a general preference for prevention over mitigation.~~ Single failure criterion shall be considered.

~~Redundant, diverse purge air supplies are provided for the IX column hydrogen mitigation system.~~ The primary purge air source is provided by the instrument air service. Should the plant instrument air supply fail or be inadvertently valved out, backup air is provided by the ITS purge air system. Flow elements detect loss of flow in the purge air line to the ~~column~~ siphon-break and valve in the ITS backup supply should the primary supply be lost. The ITS purge air supply is fed by multiple air compressors and is connected to emergency power. The ITS purge air to the ~~column~~ siphon break is supplied through two parallel valve trains to ensure a single valve or interlock failure can not disable purge airflow. The regulating valves in each train are to be designed to ensure the minimum calculated airflow to ensure the ~~column vapor space~~ siphon break remains at or below 1 %. The purge air exhaust paths from each column have parallel regulating valves to prevent single failures from blocking the exhaust path.

The ITS purge air system is concluded to meet the defense in depth requirements. The active portions (valves, interlocks) of the system ~~meet the single failure criterion, as they~~ are arranged in a redundant parallel configuration. The two trains are considered to supply the required two physical barriers to release. The secondary confinement system provided by the cell walls and C5 ventilation system provides an additional barrier to release ~~(conventional defense in depth)~~.

Required Modifications: For clarity and correctness, the following sentences must be deleted:

"The purge air exhaust paths from each column have parallel regulating valves to prevent single failures from blocking the exhaust path.

The ITS purge air system is concluded to meet the defense in depth requirements. The active portions (valves, interlocks) of the system are arranged in a redundant parallel configuration. The two trains are considered to supply the required two physical barriers to release. The secondary confinement system provided by the cell walls and C5 ventilation system provides an additional barrier to release."

The deleted sentences must be replaced with the following:

"The ITS purge air system is concluded to meet the single failure criterion because the active portions (valves, interlocks) of the system are arranged in a redundant parallel configuration to ensure a single valve or interlock failure cannot disable purge airflow. The physical integrity of the purge air piping, isolation valves, and backflow-preventing devices, in addition to the barrier provided by the cell structure and C5 ventilation system, provide the required two physical barriers to release.

Level control of the column is provided by four level sensors in the hydrogen mitigation system, two credited (LS-1 and LS-4) and two not credited (LS-2 and LS-3). Although the credited SS LS-1 sensor is not required to meet the single failure criterion in accordance with the SRD, defense in depth is provided by the two process control level sensors (LS-2 and LS-3) and the credited SS gas collection piping flushing system and the credited SS nitrogen inerting system. Operation of the weak caustic flushing system submerges the sensors, as well as the LS-2 and LS-3 sensors. A lack of confirmation of submergence by any one sensor indicates a failure. There are no hazards associated with a sensor failure in this case since flushing (which causes sensor submergence) removes the potentially explosive gases from the system. The subsequent operation of the nitrogen inerting system exposes both the LS-1 and LS-2 sensors to nitrogen gas. The lack of confirmation of both the LS-1 and LS-2 sensors to the presence of gas indicates a failure. Again there are no hazards because the gas collection piping contains only inert gas at this point. Thus, the lack of any hazards associated with the failure of the LS-1 sensor obviates the need for additional controls to satisfy the single failure criterion for the LS-1 sensor.

Although the credited SS LS-4 sensor also is not required to meet the single failure criterion, defense in depth for this sensor is provided by the LS-3 sensor, whose exposure to gas signals the need for automatic flushing of the gas collection piping. The exposure of the LS-4 sensor to gas also signals the need to automatically stop the column pump and vent the column to the break pot. Thus, both the LS-3 and LS-4 sensors must fail together for unacceptable levels of hydrogen to build up in the collection piping. The double failure required to produce a hazard was determined to be a sufficient basis to not require additional control(s) to satisfy the single failure criterion for the LS-4 sensor. The physical integrity of the sensors, the gas collection piping, the isolation valves, the PVV system piping, and the PVV HEPA filters, in addition to the barrier provided by the cell structure and C5 ventilation system, provide the required two physical barriers to any release from the level control system."

Evaluation (Acceptable as modified): The reviewers concluded that the deletions in this section were acceptable since all dealt with the obsolete hydrogen mitigation system or the requirements of the former safety classification system. The first sentence of the ORP-required deletions also pertained to the obsolete hydrogen mitigation system. The reviewers agreed with the additions (as modified) since they adequately describe the controls and operation of the new hydrogen mitigation system, the required two physical barriers to release, and how the single failure criterion was considered. The reviewers concluded that satisfying the single failure criterion for the level control system was unnecessary because there are no hazards associated with the single failure of the LS-1 sensor and because the single failure of the LS-4 sensor requires the concomitant failure of the LS-3 process control sensor to create a hazard. See COA Nos. 1 through 4 in Section D of this SER for issues that may impact the ability of the Cs IX Hydrogen Mitigation System to perform its safety function of preventing detonations and deflagrations.

3.4.1.8.4.8 Conclusion

An ITS purge air system is used to prevent flammable accumulation of hydrogen gas in the ~~vapor spaces~~ siphon break of the cesium ion exchange columns in the advent that the collection piping system has being put into a vent mode. The ITS purge air system backs up the normal purge air flow used to control liquid level in the columns. The ITS purge air is activated whenever the normal purge airflow is insufficient to maintain column headspace below 25 % of the LFL. The ITS purge system active components are redundant and meet the single failure criterion, ensuring reliable operation. A hydrogen burn in the cesium ion exchange columns is considered beyond design basis.

Flammable gas accumulation in the ~~vapor space~~ siphon break of a cesium ion exchange column is considered to be adequately prevented by ITS design features and TSR controls. The radiological exposure standards do not apply to prevented events. The defense in depth requirements are met by the ITS purge air design.

Required Modifications: For clarity and correctness, the two paragraphs above must be deleted and replaced with the following:

"An ITS purge air system is used to prevent a flammable accumulation of hydrogen gas in the siphon break of the cesium ion exchange columns in the event the collection piping system has been placed into a vent mode. The ITS purge air system backs up the normal purge air flow used to purge the siphon break. The ITS purge air is activated whenever the normal purge airflow is insufficient to maintain the siphon break below 25 % of the LFL. The ITS purge system active components are redundant and meet the single failure criterion, thereby ensuring reliable operation. A hydrogen burn in the siphon break is considered to be adequately prevented by ITS design features and TSR controls. The radiological exposure standards do not apply to prevented events. The defense in depth requirements are met by the ITS purge air design.

An ITS level control system is used to prevent a flammable accumulation of hydrogen gas in the gas collection piping. The ITS level sensors are backed up by process control sensors, providing defense in depth but not satisfying the single failure criteria. Hazards associated with the failure of the level control system are adequately prevented by the need for at least *two simultaneous failures, one involving an ITS control and another a process control. The ITS nitrogen inerting system, ITS caustic flushing system, and ITS isolation valves provide the ability to mitigate gas buildups in the gas collection piping."*

Evaluation (Acceptable as modified): The reviewers concluded the deletions in this section are acceptable since all dealt with the obsolete hydrogen mitigation system. Other ORP-required deletions also pertained to the obsolete hydrogen mitigation system. The reviewers concluded the additions (as modified) are acceptable since they adequately describe the controls and operation of the new hydrogen mitigation system to prevent a potential deflagration or detonation. See COA Nos. 1 through 4 in Section D of this SER for issues that may impact the ability of the Cs IX Hydrogen Mitigation System to perform this safety function.

3.4.2.1 Seismic Event
3.4.2.1.3 Consequence Calculation
Chemical Consequences

The ~~SIPD shows that the~~ unmitigated chemical consequences from an NOx release during CXP system regeneration can exceed chemical exposure standards. As discussed in section 3.4.2.1.1, the NO_x release requires the seismic failure of the Cs IX screen. However, the SS Cs IX columns are designed to Seismic Category (SC)-IIII so the screen can be credited with not failing during an earthquake (Note: Column are actually designed to SC-I) . Therefore, the generation of the hazardous chemical is prevented, and the mitigated chemical consequences are below exposure standards.

Required Modifications: For clarity and correctness, the paragraph above must be deleted and replaced with the following:

"The unmitigated chemical consequences from a NOx release during CXP system regeneration can exceed chemical exposure standards. As discussed in Section 3.4.2.1.1, the NO_x release requires the seismic failure of the Cs IX screen. The SS Cs IX columns are designed to Seismic Category (SC)-III in accordance with Safety Criterion 4.1-3 for chemical hazards so the resin screen can be credited with not failing during an earthquake. Therefore, the generation of NOx is prevented, and the mitigated chemical consequences are below exposure standards. A comparison between the consequences of unmitigated and mitigated scenarios is given below."

Evaluation (Acceptable as modified): The reviewers concluded the deletion in this section regarding the SIPD is not relevant to the authorization basis. The ORP-required changes clarify the seismic requirements for the IX columns.

Cs IX Column and Spent Resin Collection Vessel Events
There are three potential accidents affecting Cs IX columns and one affecting the spent resin collection vessel.

The Cs IX columns are classified as SC-IIII, but they are being procured at SC-1 and are being provided with SC-I hydrogen mitigation. Consequently, neither the IX column fire (which requires a seismic failure to drain the column) ~~n~~or the IX column explosion (which requires hydrogen accumulation) ~~can~~ could be seismically induced.

Required Modifications: For clarity and correctness, the paragraph above must be deleted and replaced with the following:

"The Cs IX columns are classified as SC-III because neither the IX column fire (which requires a seismic failure, improperly connected jumper, or maintenance accident to drain the column) nor the IX column explosion (which requires hydrogen accumulation) could be seismically induced. The IX column fire is prevented by actions (such as elution or transfer of the resin to a safer location) taken during the 110-hour minimum response time. The IX column explosion is prevented by the ITS hydrogen mitigation system.

Evaluation (Acceptable as modified): The reviewers concluded that the changes as modified are acceptable because a fire is precluded by the long response time allowed to restore safe conditions and the explosion is precluded by the ITS hydrogen mitigation system.

Credited SSCs

For chemical consequences, the seismic control strategy consists of designating the Cs IX columns (CXP-IXC-00001/2/3/4) as ITS and SC-III in accordance with Safety Criterion 4.1-3 of the SRD. These columns are already designed to ~~ated as~~ SC-I loads, so the current seismic control strategy for chemicals is sufficient.

For radiological consequences, the seismic control strategy consists of designating the SSCs credited in the mitigated consequence calculations as ITS and SC-I in accordance with Safety Criterion 4.1-3 of the SRD. The specific SSCs making up the seismic control strategy are identified in Table 3A-13 and summarized below:

- ~~Cs IX columns (CXP-IXC-00001/2/3/4) and associated piping~~
- ~~Cs IX columns (CXP-IXC-00001/2/3/4) hydrogen mitigation~~

Evaluation (Acceptable): Although Cs IX columns were evaluated and found acceptable to be designated as SC-III as evaluated in Section C.1 in this SER, the Contractor decided to procure the columns as meeting a SC-I load. This added conservatism in the design was acceptable to the reviewers.

Bounding Environmental Conditions

The bounding environmental condition for the SSCs that are depended upon to ensure radiological exposure standards are not exceeded is the design basis earthquake. This is based on Safety Criterion 4.1-3 of the SRD. This Safety Criterion specifies that SSCs required to prevent exceeding public radiological exposure standards are to be designed as SC-I, which is based on the design basis earthquake.

Evaluation (Acceptable): The reviewers agreed with the addition of the word "public" to the final sentence above because it is consistent with the new safety classification and seismic category designation. The discussion above pertains to the seismic event involving the whole PT facility, and is not solely related to the CXP system.

4.3.3 Vessels, and Evaporator Separators~~, and Cs IX Columns~~ (H_2 Hazards)

SDC process vessels, evaporator separators~~, and Cs ion exchange (IX) columns~~ that provide primary confinement of wastes that pose a significant hydrogen accumulation hazard are identified below. SDC process vessels credited for hazards requiring confinement are identified in section 4.3.18.

Equipment Requiring Mixing and H_2 Purging	Equipment Requiring H_2 Purging
Waste feed evaporator separator vessels * (FEP-SEP-00001A/B)	Cs evaporator separator vessel (CNP-EVAP-00001)
Waste feed evaporator feed vessels (FEP-VSL-00017A/B)	Eluant contingency storage vessel (CNP-VSL-00003)
	Cs IX feed vessel (CXP-VSL-00001)
HLW lag storage vessels (HLP-VSL-00027A/B)	~~Cs IX columns (CXP-IXC-00001/2/3/4)~~
HLW feed blending vessel (HLP-VSL-00028)	
Ultimate overflow vessel (PWD-VSL-00033)	Spent resin slurry vessels (RDP-VSL-00002A/B/C)
HLW effluent transfer vessel (PWD-VSL-00043)	
Plant wash vessel (PWD-VSL-00044)	Ultrafilter permeate vessel (UFP-VSL-00062A/B/C)
Ultrafiltration feed preparation vessels (UFP-VSL-00001A/B)	Waste feed receipt vessels (FRP-VSL-00002A/B/C/D)
Ultrafiltration feed vessels (UFP-VSL-00002A/B)	
HLW feed receipt vessel (HLP-VSL-00022)	

* FEP-SEP-00001A/B solids are suspended during normal operations by recirculation pumps; see section 4.3.4.

Evaluation (Acceptable): The reviewers concluded the deletions are acceptable as they are consistent with the new SS safety classification of the Cs IX columns evaluated in Section C.1 of this SER.

4.3.3.1 Credited Safety Function

The credited SDC safety functions of the process vessels, evaporator separators~~, and Cs IX columns~~ are to provide primary confinement of process materials and to maintain an intact connection with the hydrogen purge, dilution, and mixing systems.

Evaluation (Acceptable): The reviewers concluded the deletion is acceptable as it is consistent with the new SS safety classification of the Cs IX columns evaluated in Section C.1 of this SER.

4.3.4.2 System Description

The process vessels, evaporator ~~separators, and IX columns~~separators listed in section 4.3.3 require hydrogen purging, dilution, and/or mixing. They were selected based on the time to reach the lower flammability limit (LFL) following a loss of hydrogen purging (3000 hours) or the amount of suspended solids in the vessel contents that may trap and later release hydrogen gas (≥ 5 weight percent). (Note that non-ITS mixing of vessels containing less that 5wt% suspended solids is an assumption requiring verification.) All of the designated vessels (except the evaporator separator vessels) will have normal air purge, dilution, and/or mixing using the ITS components supplied with instrument and plant air. Instrument air is used to operate control valves for ITS purge/mixing. The ITS air supply will serve as a backup air source.

> Evaluation (Acceptable): The reviewers concluded the deletion is acceptable since the IX columns no longer require hydrogen purging, dilution, and/or mixing as was the case for the obsolete hydrogen mitigation system.

4.3.4.6 Controls (TSRs)

The forced purge air supply provides air to the PJMs and the headspace purge. Surveillances will be required to verify air supply operability. Surveillances also will be required to verify operability of the FEP separator vessel drain line isolation valves. Equipment used in the surveillances will be controlled by a measurement and test equipment program addressed as an administrative control in the TSRs.

The FRP waste feed receipt vessels are assumed to not require ITS mixing of their contents for hydrogen mitigation. A TSR administrative control prohibiting the FRP vessels from receiving waste containing suspended solids ≥5 weight percent will be established to protect the assumption.

~~A 150,000 Ci Cs-137 bed loading limit will be established to provide a ceiling for determining the maximum hydrogen generation rate in the Cs IX columns. The resin bed loading limit will be protected by a TSR administrative control to maintain the safety envelope of the column within analyzed boundaries.~~

The components credited for ~~providing emergency elution of Cs IX columns, the~~ CNP recirculation piping, and the FEP evaporator separator vessel components for potentially draining to a vessel for solids mixing (hydrogen mitigation) also are designated SDC.

> Evaluation (Acceptable): The reviewers concluded that deletion of the two sentences regarding Cs IX column loading limits and its protection is acceptable since the IX columns have been deleted as SDC subjects of this section (Section 4.3.4). The reviewers noted that the deleted sentences were still relevant and required that they be in incorporated in the revised Section 4.4.14, Cs IX Columns (H2 Hazards) (SS).

4.3.5.2 System Description

The components credited for ~~providing emergency elution of Cs IX columns, the~~ CNP recirculation piping, and the FEP evaporator separator vessel components for potentially draining to a vessel for solids mixing (hydrogen mitigation) also are designated SDC.

Evaluation (Acceptable): The reviewers concluded that the deletion of the emergency elution system as SDC is acceptable since the proposed SS safety classification was evaluated and found acceptable in Section C.1 of this SER.

4.3.6 Process Vessel Cooling Jackets, and Evaporator Separator Reboilers~~, and IX Feed Coolers~~

4.3.6.1 Credited Safety Function

The credited safety function of SDC vessels with cooling jackets, evaporator separator reboilers~~, and IX feed coolers~~ is to provide primary confinement of process liquids, the release of which to service systems could exceed RES to facility workers.

4.3.6.2 System Description

The following reboilers ~~and IX feed coolers~~ are designated SDC:

~~•Cs Ion Exchange Feed Coolers (CXP-HX-00001A/B)~~

The vessels, reboilers~~, and IX feed coolers~~ are described in section 2.5 of this document.

4.3.6.3 Functional Requirements

To ensure that process vessels with cooling jackets, reboilers~~, and IX feed coolers~~ perform their credited safety functions, the following functional requirements must be met:

- The reboilers ~~and IX feed coolers~~ must maintain an intact boundary between the heating steam/cooling fluid and the process fluids.

The vessels, reboilers ~~and IX feed coolers~~ have a seismic safety function, are designated SC-I, and must meet SRD Safety Criteria 1.0-5, 3.2-1, 4.1-2, 4.1-3, 4.1-4, 4.2-1 through 4.2-3, 4.3-4 and 4.4-2. SDC SSCs must meet QL-1 requirements.

4.3.6.4 Standards

The following standards apply to vessels with cooling jackets, and the evaporator separator reboilers~~, and IX feed coolers~~:

- The reboiler ~~and Cs IX feed cooler internals~~ internals will be designed in accordance with TEMA Type B, *Standards for Heat Exchangers*. TEMA Type B is an industry standard that sets design requirements for heat exchanger internals.

4.3.6.5 System Evaluation

The process vessel cooling jackets are required to maintain an intact boundary with the vessel. The criteria is met by designing the vessel and associated cooling jacket to ASME, section VIII, and using 316 L stainless steel as the material of construction in accordance with ASME, section II. In addition, the vessels and jackets are designed, fabricated, inspected, and tested in accordance with an approved quality control system. These design features and the process followed to ensure that these features are incorporated, along with the full welding of the confinement boundary, all ensure a high integrity, long life vessel. The evaporator separator reboilers ~~and IX feed coolers~~ undergo the same rigorous design and fabrication process to ensure their integrity.

Evaluation (Acceptable): The reviewers concluded that the IX feed coolers addressed in Section 4.3.6 subsections are not SDC components and can be deleted from this section because the proposed SS safety classification of feed coolers was evaluated and found acceptable in Section C.1 of this SER.

~~4.3.9 Ion Exchange Column Liquid Level Protection System~~

~~4.3.9.1 Credited Safety Function~~

~~The credited safety function of the Cs IX column liquid level protection system is to maintain the column at a liquid level that prevents resin heat up to the point of thermal degradation or autoignition.~~

~~4.3.9.2 System Description~~

~~The IX columns remove Cs from the waste stream to be processed in the LAW vitrification facility. Cs decay heat is normally removed by flowing liquid through the columns. Should a highly loaded column lose liquid or dry out over an extended time frame, the resin media may overheat. Heat transfer in the resin bed of a dry column will be compromised due to the presence of insulating "dead" air in the void spaces between the resin particles. If the centerline temperature of the resin is elevated, it is possible that the organic resin may thermally degrade (pyrolyze) or autoignite.~~

~~The Cs IX column liquid level protection system will ensure that the required column liquid level will be maintained under column leak, idle, or loss of liquid level control (blowout) conditions. The system includes~~

- ~~Column liquid level detection and column resin bed temperature monitoring instrumentation~~
- ~~Emergency elution system interlock~~
- ~~Emergency elution system (including vessels, piping, valves, instrumentation)~~
- ~~Cs fresh resin air gap vessel level detection~~
- ~~Column isolation valve interlock~~
- ~~Column feed pump valve interlock~~
- ~~Column hydrogen purge control system~~
- ~~Redundant hydrogen purge exhaust paths~~

~~4.3.9.3 Functional Requirements~~

~~To ensure that the Cs IX column liquid level protection system performs its credited safety function, the following functional requirements must be met:~~

- ~~On detection of low liquid level in an IX column or high temperature in the column resin bed, the liquid level or resin bed temperature interlock must~~
  - ~~Initiate the emergency elution system~~
  - ~~Close the column inlet and outlet valves, or close the IX column feed pump suction and discharge valves.~~
- ~~The Cs fresh resin air gap vessel level detection must indicate that elution reagents are being provided to the IX columns.~~

- ~~On initiation of the emergency elution system, the fresh resin addition valve at the outlet of CRP-VSL-00001 must close.~~
- ~~On detection of low liquid level in an IX column (level below the column top), the column hydrogen purge control system must default to a low pressure state.~~
- ~~The emergency elution system vessels, piping, and valves must provide an open flow path to the resin bed for caustic solution, demineralized water, and elution acid.~~
- ~~The redundant hydrogen purge exhaust system must maintain an open flow path.~~
- ~~The system must be provided with SDC UPS power as necessary to perform its safety function upon a loss of normal power.~~

~~The system design must satisfy the single-failure criterion. The Cs IX column liquid level protection system has a seismic safety function, is designated SC-I, and must meet SRD Safety Criteria 4.1-2, 4.1-4, 4.3-1 through 4.3-5, 4.4-1, 4.4-2, 4.4-3, and 4.4-4. SDC SSCs must meet QL-1 requirements.~~

~~The functional requirements applicable to the emergency elution vessels, piping, and valves are specified in sections 4.3.3.3 and 4.3.5.3. The functional requirements applicable to the column hydrogen purge control system are specified in section 4.3.4.3.~~

~~4.3.9.4 Standards~~

~~The following standards apply to the Cs IX column liquid level protection system:~~

- ~~The level protection system will be designed and constructed in accordance with ISA S84.01, IEEE 338, IEEE 344, IEEE 379, IEEE 384, and IEEE 1023.~~

~~The rationale for selecting ISA S84.01 and the IEEE standards is provided in section 4.3.2.4.~~

~~The standards applicable to the emergency elution vessels, piping, and valves are specified in sections 4.3.3.4 and 4.3.5.4. The standards applicable to the column hydrogen purge control system are specified in section 4.3.4.4.~~

~~4.3.9.5 System Evaluation~~

~~The Cs IX liquid level and resin bed temperature instrumentation and controls interlocks will be designed using the cited standards to ensure the reliability of the safety system to perform the necessary functions of detecting low level or high resin temperature. This instrumentation will initiate the emergency elution system to elute the resin of~~ ^{137}~~Cs. The Cs fresh resin air gap vessel level detection will indicate that elution reagents are reaching the IX columns.~~

~~The interlocks also will shut the column inlet and outlet isolation valves, or close the column feed pump isolation valves. The low-level detection interlock also initiates a column pressure reduction by the hydrogen purge control system to ensure the addition of the emergency elution chemicals.~~

~~This level control system of interlocks will protect resin, potentially loaded with Cs, from heating to the point of thermal degradation or autoignition. The SDC UPS power is designed to the cited IEEE standards to ensure the reliability of the level instrumentation detection system.~~

~~4.3.9.6 Controls (TSRs)~~

~~The Cs IX column liquid level protection system must be operable whenever the Cs IX columns contain ^{137}Cs-bearing waste. Surveillances will be required to maintain the reliability of this SSC. The SDC UPS will also require surveillances to verify its operability. Equipment used in the surveillances will be controlled by a measurement and test equipment program addressed as an administrative control in the TSRs.~~

Evaluation (Acceptable): The reviewers concluded that deletion of this section is acceptable because it pertains to the obsolete hydrogen mitigation system.

~~4.3.14 Nitric Acid Concentration Monitors and Interlocks~~

~~4.3.14.1 Credited Safety Function~~

~~The credited safety function of the nitric acid concentration monitors and interlocks is to prevent the transfer of greater than 3 M nitric acid into the Cs IX columns during elution. The addition of concentrated nitric acid into the Cs IX columns could cause exothermic reactions with resins and produce large amounts of offgas and release of radioactive materials.~~

~~4.3.14.2 System Description~~

~~*4.3.14.2.1 Rectifier Nitric Acid Concentration Monitor and Interlock*~~

~~Cs eluate from the IX process is delivered to the Cs evaporator separator vessel (CNP-EVAP-00001) for concentration of Cs salts and recovery of eluant. The vapor leaving the Cs evaporator separator vessel contains water and nitric acid. Passing the vapor through the rectifier (CNP-DISTC-00001) increases the concentration of the recovered acid. The recovered acid flows from the bottom of the rectifier to the Cs evaporator nitric acid recovery vessel (CNP-VSL-00004) from which it can be transferred to a Cs IX column for elution. A multiple combination of faults could over-concentrate nitric acid in the evaporator, leading excessively concentrated acid to be used in eluting the Cs IX columns.~~

~~A nitric acid concentration monitor is located in the downcomer between the evaporator rectifier and the Cs evaporator nitric acid recovery vessel. The monitor (conductivity probe or density meter) is interlocked with the Cs IX feed pump (CXP-PMP-00001A/B) isolation valves. Closing the valves on detection of an acid concentration of 3 M or greater will stop the transfer of the concentrated nitric acid to the Cs IX columns.~~

~~*4.3.14.2.2 Reagent Addition 2 M Nitric Acid Monitor and Interlock*~~

~~Depending on the Cs evaporator separator vessel operating conditions, the acid concentration in the Cs evaporator nitric acid recovery vessel (CNP-VSL-00004) may fall below 0.5 M, the design elution concentration. Two M acid can be added via the reagent addition system to increase the acid concentration to the design value. The reagent addition system is supplied with 2 M nitric acid from the BOF acid dilution station. It is possible for the nitric acid to be inadequately diluted before transfer to the Cs evaporator nitric acid recovery vessel.~~

~~A nitric acid concentration monitor is located in the PT facility on the reagent addition system header which feeds 2 M nitric acid to the Cs evaporator nitric acid recovery vessel. The monitor is interlocked with isolation valves in the line. Closing the valves on detection of an acid concentration of 3 M or greater will stop the transfer of the concentrated nitric acid to the Cs evaporator nitric acid recovery vessel.~~

~~4.3.14.2.3 Reagent Addition 0.5 M Nitric Acid Monitor and Interlock~~

~~The nitric acid head tank NAR-TK-00007 will be charged with 0.5 M nitric acid for emergency elution of the Cs IX columns. The BOF dilution station will provide the acid to the tank via the reagent addition system. It is possible for the nitric acid to be inadequately diluted before transfer to the nitric acid head tank.~~

~~A nitric acid concentration monitor is located in the PT facility on the reagent addition system line to the nitric acid head tank. The monitor is interlocked with isolation valves in the line. Closing the valves on detection of an acid concentration of 1 M or greater will stop the transfer of the concentrated nitric acid to the nitric acid head tank. The 1 M setpoint will prevent nitric acid in NAR-TK-00007 from self-concentrating to 3 M or greater. Also, monthly sampling of the tank will verify the nitric acid is not over-concentrated.~~

~~4.3.14.3 Functional Requirements~~

~~To ensure that the nitric acid concentration monitors and interlocks perform their credited safety function, the following functional requirements must be met:~~

~~4.3.14.3.1 Rectifier Nitric Acid Concentration Monitor and Interlock~~

- ~~The monitor on the downcomer between the evaporator rectifier, CNP-DISTC-00001, and the Cs evaporator nitric acid recovery vessel, CNP-VSL-00004, must be interlocked to the Cs IX feed pump isolation valves.~~
- ~~The monitor must signal the interlock to close the Cs IX feed pump isolation valves upon detecting a nitric acid concentration of 3 M or greater.~~
- ~~The monitor and interlock must be provided with SDC UPS electrical power as necessary to perform its safety function.~~

~~The rectifier nitric acid concentration monitor and interlock in conjunction with the Cs evaporator separator vessel temperature monitor and interlock (section 4.4.12) meet the single-failure criterion.~~

~~4.3.14.3.2 Reagent Addition 0.5 and 2 M Nitric Acid Concentration Monitors and Interlocks~~

- ~~The reagent addition nitric acid concentration monitors must be interlocked to isolation valves in the reagent addition piping.~~
- ~~The 0.5 M concentration monitors must signal the interlocks to close the isolation valves upon detecting a nitric acid concentration of 1 M or greater.~~
- ~~The 2 M concentration monitors must signal the interlocks to close the isolation valves upon detecting a nitric acid concentration of 3 M or greater.~~
- ~~The monitors and interlocks must be provided with SDC UPS electrical power as necessary to perform their safety functions.~~

~~The reagent addition nitric acid concentration monitors and interlocks must meet the single failure criterion.~~

~~The concentration monitors and interlocks do not have a seismic safety function and are classified SC-III. They will be designed to meet SRD Safety Criteria 4.1-2, 4.1-4, 4.3-1 through 4.3-5, 4.4-1, 4.4-2, 4.4-3, and 4.4-4. SDC SSCs must meet QL-1 requirements.~~

~~4.3.14.4 Standards~~

~~The nitric acid concentration monitors and interlocks will be designed and constructed in accordance with ISA S84.01, IEEE 338, IEEE 379, IEEE 384, and IEEE 1023.~~

~~The rationale for selecting ISA S84.01 and the IEEE standards is provided in section 4.3.2.4.~~

~~4.3.14.5 System Evaluation~~

~~The functional requirement of the nitric acid concentration monitors and interlocks is to prevent elution of the Cs IX columns with greater than 3 M nitric acid. The performance requirement is to design the systems to monitor and initiate termination of nitric acid transfer or elution upon detecting nitric acid concentrations greater than the setpoint values. The performance requirement is met by designing the systems to ISA S84.01 and the IEEE standards.~~

~~4.3.14.6 Controls (TSRs)~~

~~The nitric acid concentration monitors and interlocks will prevent eluting the Cs IX columns with greater than 3 M nitric acid. The systems have active components and will require calibration and surveillance to maintain their reliability. The SDC UPS will require surveillances to verify its operability. Equipment used in the surveillances will be controlled by a measurement and test equipment program addressed as an administrative control in the TSRs.~~

Evaluation (Acceptable): The reviewers concluded that deletion of this section is acceptable because nitric acid controls to prevent unacceptable reactions with Cs IX resin are addressed adequately in the SED.

4.3.17 ~~Cs Ion Exchange Process (CXP) and~~ Cs Nitric Acid Recovery Process (CNP) System~~s~~

~~Cs IX columns contain resins that can overheat and autoignite following a loss of cooling. Also, if concentrated acids or permanganates mix with the Cs IX column resins, an exothermic reaction can occur causing pressurization and possible release of radioactive materials.~~

4.3.17.1 Credited Safety Function

~~The credited SDC safety function of the Cs IX process (CXP) system design is to ensure that the Cs IX column liquid level does not drop below the top of the resin bed during an idle period.~~

4.3.17.3 Functional Requirements

To ensure that the ~~CXP and~~ CNP system~~s~~ perform their credited safety functions, the following functional requirements must be met:

- ~~The hydraulic design of the Cs IX columns and associated upstream and downstream vessels must ensure that the liquid level in a column remains at or above the column feed distributor height upon loss of feed flow during an idle period.~~
- The ~~CXP and~~ CNP system~~s~~ must maintain their integrity following a design basis earthquake.

The ~~CXP and~~ CNP systems have a seismic safety function, are designated SC-I, and must meet SRD Safety Criteria 1.0-5, 3.2-1, 4.1-2, 4.1-3, 4.1-4, 4.2-1 through 4.2-3, 4.3-4 and 4.4-2. SDC SSCs must meet QL-1 requirements.

4.3.17.5 System Evaluation

The functional requirement for the ~~CXP system is to maintain the liquid level in the Cs IX columns and for the~~ CNP system to prevent concentrated acid from overflowing into the Cs IX columns. The performance criterion used in the accident analysis is the hydraulic design of ~~both the~~ system~~s~~ and is met by design activities using known principles of fluid mechanics and the design review process.

4.3.17.6 Controls (TSRs)

The ~~CXP and~~ CNP system~~s~~ will be ~~hydraulically~~ designed to ~~maintain liquid level in the columns while idle and to~~ prevent overflow of 5 to 8 M nitric acid from the CNP breakpot into the evaporator, rectifier, and Cs IX columns.

> Evaluation (Acceptable): The reviewers concluded that the deletions in Section 4.3.17 and its subsections are acceptable because they pertain largely to the obsolete hydrogen mitigation system. The revised section now addresses only the CNP system. Text relevant to the CXP system has been addressed in Section 5.6.9, Cs Ion Exchange Process (CXP) and Cs Nitric Acid Recovery Process (CNP) Systems

4.3.18.2 System Description

The following process vessels are designated SDC:

- ~~Cs IX Treated LAW Collection Vessels (CXP-VSL-00026A/B/C)~~

> Evaluation (Not evaluated): Based on the communication between ORP and the Contractor in CCN 100638, the Contractor has decided to retract the proposed change that Cs IX Treated LAW Collection Vessels not be designated as SDC. The Contractor stated that further evaluation is required because these vessels could be potential hydrogen generators.

~~4.4.13 Cs IX Feed Cooler Chilled Water Pressure Monitoring Instrumentation and Interlocks~~

~~4.4.13.1 Credited Safety Function~~

~~The credited safety function of the Cs IX feed cooler chilled water pressure monitoring instrumentation and interlocks is to shut down the Cs IX feed pumps on detecting low chilled water pressure that indicates a reduction in the differential pressures between the chilled water system and the process vessel pressures. Reduced chilled water pressure could allow radioactive process materials to enter the chilled water system if the feed cooler wall separating the process and chilled water sides is failed. Facility workers in the vicinity of radioactively contaminated chilled water system components located in occupied areas could be exposed to both direct radiation from the activity in the water and airborne contamination evolved from a vented expansion tank or from water spills or leaks.~~

~~4.4.13.2 System Description~~

~~Chilled water from BOF is supplied to a closed loop chilled water system in the PT facility. The BOF chilled water removes heat from the PT CHW system, which cools PT components with high heat loads. The system consists of chilled water pumps, booster pumps, heat exchangers, distribution piping to groups of cooled components, and an expansion tank. The CHW system pressure is maintained, during normal operations, at levels that ensure contaminated fluids cannot leak from the process systems into the Cs IX feed coolers (CXP-HX-00001A/B). The hydraulic heads on the chilled water sides of the IX feed coolers are maintained higher than the process vessel sides. Pressure monitoring instrumentation on the chilled water system signal interlocks to shutdown the Cs IX feed pumps (CXP-PMP-00001A/B) on low system pressure.~~

~~4.4.13.3 Functional Requirements~~

~~To ensure that the Cs IX column feed cooler chilled water pressure monitoring instrumentation and interlocks perform their credited safety functions, the following functional requirements must be met:~~

- ~~The pressure monitoring instrumentation must detect chilled water pressure at or below the setpoint value and signal the pump shutdown interlocks.~~
- ~~The pressure monitoring instrumentation and pump shutdown interlocks must be provided with SDC UPS electrical power as necessary to perform their safety functions.~~

~~The system has no seismic safety function. The system is designated SC-III and must meet SRD Safety Criteria 4.1-2, 4.3-1, 4.3-3, 4.3-4, 4.4-1, and 4.4-2. SDS SSCs must meet QL-2 requirements.~~

~~4.4.13.4 Standards~~

~~The pressure monitoring instrumentation and pump shutdown interlocks will be designed in accordance with ANS 58.8, IEEE 338, IEEE 1023, and ISA S84.01.~~

~~ANS 58.8 is the standard applied to all SDC or SDS safety functions that require instrumentation in order to support credited safety-related operator actions. IEEE 338 is applied to design safety instrumented systems so they can be tested to prove their required safety functions. IEEE 1023 is applied to all safety functions requiring indication and/or alarm at a safety qualified operator interface. ISA S84.01 provides guidance for design of operator interfaces.~~

~~4.4.13.5 System Evaluation~~

~~Insufficient pressure in the chilled water system could lead to contamination migration into potentially occupied areas of the plant. The pressure monitoring instrumentation and pump shutdown interlocks will ensure that process pressures are quickly reduced to prevent or minimize the amount of contaminated material migrating to the chilled water system. The standards cited provide design criteria to ensure the Cs IX column feed cooler chilled water pressure monitoring instrumentation and interlocks perform their credited safety functions.~~

~~4.4.13.6 Controls (TSRs)~~

~~Chilled water pressure will be continuously monitored and upon detection of low pressure, interlocks will shutdown the Cs IX feed pumps. The systems have active components and will require calibration and surveillance to maintain their reliability. The SDC UPS will also require~~

~~surveillances to verify its operability. Equipment used in the surveillances will be controlled by a measurement and test equipment program addressed as an administrative control in the TSRs.~~

Evaluation (Acceptable): The reviewers concluded that deletions of the above Section 4.4.13 subsections are acceptable because the Feed Cooler Chilled Water Pressure Monitoring Instrumentation and Interlocks are no longer credited as the control for the chilled water system as evaluated in Section C.1 of this SER.

4.4.14 Cs IX Columns (H2 Hazards) (SS)

SS Cs ion exchange (IX) columns that provide primary confinement of wastes that pose a significant hydrogen accumulation hazard are identified below.

Equipment Requiring H_2 Purging
CRP siphon break downstream of CRP bulge-00001 (Cs IX hydrogen mitigation bulge)

4.4.14.1 Credited Safety Function

The credited SS safety functions of the Cs IX columns are to provide primary confinement of process materials and to maintain an intact connection with the hydrogen mitigation, and emergency elution systems.

4.4.14.2 System Description

The Cs removal system consists of four IX columns, each containing an equal volume of resin. In loading mode, three of the columns are connected in series (a “train”) processing low-activity waste feed. In this configuration:

- The first column of the loading train is in “lead” position
- The second column is in “lag” position
- The third and final column is in “polishing” position
- The fourth column is off-line for elution and regeneration, or is in standby

At some point in processing low-activity waste, the removal efficiency of the lead column is reduced. Eventually, the Cs concentration in the effluent stream exiting the polishing column will increase to a level approaching the predetermined maximum. When the predetermined maximum is reached, the valving will be changed.

The column previously in the lead position is eluted and regenerated. After regeneration, the column will be in standby until it is returned to the train as the polishing column.

After several loading and regeneration cycles, the IX resin is expected to lose performance and is considered to be “spent”. The number of cycles depends on low-activity waste constituents, operating temperatures, properties of IX resin batches, and low-activity waste throughput rates. To remove the spent IX resin, it is slurried with recycled IX resin flush solution and flushed out of the column into the spent resin collection and dewatering process system (RDP) for IX resin collection and disposal. A slurry of fresh IX resin prepared in the cesium resin addition process system (CRP) is then added to the column as a bed replacement.

4.4.14.3 Functional Requirements

To ensure that the columns perform their credited safety functions, the following functional requirements must be met:

- Remain intact with the hydrogen control system following a design basis earthquake (SC-III loads)
- Confine process liquids and aerosols with high reliability.
- Withstand a high radiation environment, the corrosive effects of the process streams, and the erosive nature of suspended solids.

The columns listed above have a seismic safety function, are designated SC-III, and must meet SRD Safety Criteria 4.1-2, 4.1-3, 4.1-4, 4.2-1 through 4.2-3, 4.4-1, and 4.4-2. SS SSCs must meet QL-2 requirements.

4.4.14.4 Standards

The following standards apply to the PT IX columns:

- The columns will be designed and constructed in accordance with *ASME Boiler and Pressure Vessel Code* (ASME), section VIII, Division 1, Pressure Vessels. This standard covers the columns, including the vessel nozzles, out to the first circumferential weld or flange.
- Columns materials will be specified in accordance with *ASME Boiler and Pressure Vessel Code*, section II, Materials Selection.

ASME Boiler and Pressure Vessel Code, Section VIII, provides a method for design, fabrication, testing, and inspection. *ASME Boiler and Pressure Vessel Code*, Section II, provides material specifications approved for use by ASME VIII. The ASME code also provides guidelines for evaluating stresses induced by internal pressure, seismic, fatigue, and effects of dynamic loadings.

4.4.14.5 System Evaluation

The functional requirement for columns that pose a significant hydrogen hazard is to maintain confinement with high reliability and intact connections to hydrogen mitigation features. The performance criterion used in the accident analysis is that the rate of a column failure resulting in leakage is equivalent to the class of stainless steel vessels used in nuclear facilities assuming no in-service inspection.

The performance criterion is met by designing the vessels to the *ASME Boiler and Pressure Vessel Code*, section VIII, using fully welded vessels fabricated of stainless steel and with specific provisions to reduce the probability of failure. The design condition used for the design of the vessels envelops the identified process conditions.

4.4.14.6 Controls (TSRs)

The columns will be designed to maintain structural integrity, considering the high-radiation environment and the corrosive and erosive nature of the process streams. The columns also will maintain their structural integrity under abnormal and accident conditions. These requirements are considered passive design features and do not require routine maintenance or surveillance to demonstrate operability. The WTP configuration management program, addressed as administrative controls in the TSRs, will ensure that the design feature will continue to fulfill its safety function.

Required Modifications: For clarity and completeness, the following text must be added:

To the end of Section 4.4.14.3, Functional Requirements; *"The SRD contains a complete listing of applicable safety criteria and the QAM specifies applicable QA requirements."* To the end of Section 4.4.14.4, Standards; *"This is a partial listing of standards. A complete listing of requirements is provided in the SRD."*

To the end of Section 4.4.14.6, Controls (TSRs); *"A 150,000 Ci Cs-137 bed loading limit will be established to provide a ceiling for determining the maximum hydrogen generation rate in the Cs IX columns. The resin bed loading limit will be protected by a TSR administrative control to maintain the safety envelope of the column within analyzed boundaries."*

For clarity and completeness, the text under Section 4.4.14.5, System Evaluation must be deleted and replaced with the following:

"The functional requirement for columns that pose a significant hydrogen hazard is to maintain confinement with high reliability and intact connections to hydrogen mitigation features. The performance criterion used in the accident analysis is based on the assumption that that the likelihood of a column leaking is equal to or less than the likelihood of leakage from the same class of stainless steel vessels used in nuclear facilities, assuming no in-service inspection.

The performance criterion is met by designing the vessels to the ASME Boiler and Pressure Vessel Code, section VIII, using fully welded vessels fabricated of stainless steel. The design condition used for the design of the vessels envelops the identified process conditions."

Evaluation (Acceptable as modified): The reviewers concluded that the additions above (as modified) are acceptable because they are consistent with the new SS safety classification for the columns' safety functions for mitigating hydrogen hazards as evaluated in Section C.1 of this SER.

4.4.15 IX Feed Coolers

4.4.15.1 Credited Safety Function

The credited safety function of SS IX feed coolers is to provide primary confinement of process liquids, the release of which to service systems could exceed RES to facility workers.

4.4.15.2 System Description

The following IX feed coolers are designated SS:

- Cs Ion Exchange Feed Coolers (CXP-HX-00001A/B)

4.4.15.3 Functional Requirements

To ensure that the IX feed coolers perform their credited safety functions, the following functional requirements must be met:

- The components must maintain their structural integrity and withstand the high radiation environment, the corrosive effects of the process streams, and the erosive nature of the suspended solids.

The feed coolers have are designated SC-III, and must meet SRD Safety Criteria 4.1-2, 4.1-3, 4.1-4, 4.2-1 through 4.2-3, 4.2-3, 4.4-1, and 4.4-2. SS SSCs must meet QL-2 requirements.

4.4.15.4 Standards
The following standards apply to the Cs IX feed-coolers:

- The components will be designed and constructed in accordance with *ASME Boiler and Pressure Vessel Code*, section VIII. This standard covers the components, including the vessel nozzles, out to the first circumferential weld or flange.
- Feed cooler materials will be specified in accordance with *ASME Boiler and Pressure Vessel Code*, section II.
- The reboiler will be designed in accordance with TEMA Type B, *Standards for Heat Exchangers*. TEMA Type B is an industry standard that sets design requirements for heat exchanger internals.

The rationale for selecting ASME sections II and VIII is provided in section 4.3.3.4.

4.4.15.5 System Evaluation
The IX feed coolers are required to maintain an intact boundary with the vessel. The criteria is met by designing the feed cooler to ASME, section VIII, and using stainless steel as the material of construction in accordance with ASME, section II.

4.4.15.6 Controls (TSRs)
The IX feed coolers will be designed for their design life, considering the high radiation environment and the corrosive and erosive nature of the process streams. The vessels are passive design features and do not require routine maintenance or surveillance to demonstrate operability. The WTP configuration management program, addressed as administrative controls in the TSRs, will ensure that the design features will continue to fulfill their safety function.

Required Modifications: For clarity and completeness, the following text must be added:

To the end of Section 4.4.15.3, Functional Requirements; *"The SRD contains a complete listing of applicable safety criteria and the QAM specifies applicable QA requirements."*
To the end of Section 4.4.15.4, Standards; *"This is a partial listing of standards. A complete listing of requirements is provided in the SRD."*

For correctness, delete the text in the third bullet under Section 4.4.15.4, Standards, and replace with the following:

- *"The feed cooler will be designed in accordance with TEMA Type B, Standards for Heat Exchangers. TEMA Type B is an industry standard that sets design requirements for heat exchanger internals."*

Evaluation (Acceptable as modified): The reviewers concluded that the above additions (as modified) are acceptable because they are consistent with the new SS safety classification for the feed coolers' confinement function evaluated in Section C.1 of this SER. The required change of the word "reboiler" to "feed cooler" corrects the misapplication of a standard.

4.4.16 Cs IX Hydrogen mitigation system

4.4.16.1 Credited Safety Function

The credited safety function of the Cs IX Hydrogen mitigation system is to prevent a potential deflagration or detonation, by maintaining accumulated hydrogen in an inert atmosphere prior to a purged siphon break.

4.4.16.2 System Description

The Cesium (Cs) Ion Exchange (IX) hydrogen mitigation system collects gas generated in the IX columns. This gas is generated by radiolytic degradation of water and the organic materials in the column; as well as, thermolytic degradation of organic materials within the columns. During normal operation, this gas (hydrogen, oxygen, carbon dioxide, and various other gases) travels up the flooded column and connecting piping to the collection-piping bulge. The collection piping in the bulge contains a minimum volume of nitrogen such that all gas collected is inert.

Whenever a specified amount of gas is collected (as indicated by level switches), and at the end of every Cs IX column operation mode, the collection piping is flushed with weak caustic and the flush liquid and gas are vented to a siphon break. The siphon-break separates the gas from liquid, directs liquid to be recycled via the PWD system, and vents the gas to the PVV system.

Level switches contained within the collection piping system will detect off-normal events such as, excessive volumes of gas, or insufficient nitrogen inerting gas. Off-normal events such as these will result in the system being flushed and having the nitrogen blanket reestablished, or being directly vented to the siphon break.

The purge air supplied to the siphon break is required to provide a gas flow 100 times the maximum gas generation rate from the column. In addition, the siphon-break headspace volume is sized to dilute excess hydrogen released from the hydrogen mitigation system to less than the lower flammability limit during off-normal events.

The Cs IX hydrogen mitigation protection system includes

- Siphon break hydrogen purge control system
- Nitrogen supply system
- Hydrogen mitigation liquid level detection monitoring instrumentation
- Redundant hydrogen purge exhaust paths

4.4.16.3 Functional Requirements

To ensure that the Cs IX hydrogen mitigation system performs its credited safety function, the following functional requirements must be met:

- A predetermined volume of nitrogen must be supplied to the collection piping system (up to Level Switch-2), prior to the system going into operation.

- The redundant hydrogen purge exhaust system must maintain an open flow path on detection of a gas bubble in the IX column piping at level switch four.
- The system must be provided with UPS power as necessary to perform its safety function upon a loss of normal power.

The Cs IX hydrogen mitigation system has a seismic safety function, is designated SC-III, and must meet SRD Safety Criteria 4.1-2, 4.1-3, 4.1-4, 4.2-2, 4.2-3, 4.3-1 through 4.3-4, 4.3-6, 4.4-1, 4.4-2, 4.4-3.

4.4.16.4 Standards

The following standards apply to the Cs IX hydrogen mitigation protection system:

- The level protection system will be designed and constructed in accordance with ISA S84.01, IEEE 338, IEEE 379, IEEE 384, and IEEE 1023.
- The piping and inline components will be designed and constructed in accordance with ASME B31.3.

4.4.16.5 System Evaluation

The Cs IX hydrogen mitigation system will be designed using the cited standards to ensure the reliability of the safety system to perform as required, the function of inerting collected hydrogen, and on detection of a gas bubble in the IX column piping of a predetermined size, the column hydrogen purge control system will vent the collection piping to a siphon break.

4.4.16.6 Controls (TSRs)

The Cs IX hydrogen mitigation system must be operable whenever the Cs IX columns contain ^{137}Cs-bearing waste above a predetermined amount. Surveillances will be required to maintain the reliability of this SSC. The UPS will also require surveillances to verify its operability. Equipment used in the surveillances will be controlled by a measurement and test equipment program addressed as an administrative control in the TSRs.

Required Modifications: For clarity and completeness, the following text must be added:

To the end of Section 4.4.16.3, Functional Requirements; *"The SRD contains a complete listing of applicable safety criteria and the QAM specifies applicable QA requirements."*
To the end of Section 4.4.16.4, Standards; *"This is a partial listing of standards. A complete listing of requirements is provided in the SRD."*

For clarity and completeness, the third paragraph under Section 4.4.16.2, System Description, must be deleted and replaced with the following:

"Level switches contained within the collection piping system will detect off-normal events such as excessive volumes of gas or insufficient nitrogen inerting gas. Off-normal events such as these will result in automatic or manual actions, depending on the event. Any event that causes the credited LS-4 level sensor to be exposed to gas will result in automatically stopping the pump that feeds the columns and opening valves to two vent paths to the siphon break. Any event that causes the credited LS-1 sensor to not detect gas when the required addition of nitrogen is injected into the collection system or to detect liquid at the LS-1 (or LS-2) sensor after nitrogen has been injected and detected at this location will result in the

same automatic actions. Any event (including normal operations) that causes the non-credited LS-3 sensor to be exposed to gas (but not LS-4) will result in automatically isolating the column from the gas collection system and flushing the collection system with weak caustic to remove the collected gas to the siphon break. Then nitrogen will automatically be recharged to the gas collection system and the isolation valve reopened, thereby re-establishing the gas collection function. Operators may elect to initiate the flushing and nitrogen inerting sequence manually, as warranted by conditions within the safety envelope."

For clarity and completeness, the text in the third bullet under Section 4.4.16.3, Functional Requirements, must be deleted and replaced with the following:

- *"The system must be provided with UPS power as necessary to perform its automatic safety function upon a loss of normal power."*

For clarity and completeness, the text under Section 4.4.16.5, System Evaluation, must be deleted and replaced with the following:

"The Cs IX hydrogen mitigation system will be designed using the cited standards to ensure the reliability of the safety system to perform, as required, the function of inerting the gas collection piping. On detection of a gas bubble in the IX column piping of a predetermined size below the size capable of a detonation or deflagration, the column hydrogen purge control system will vent the gas in the collection piping to a siphon break."

For clarity and completeness, the text in the first sentence under Section 4.4.16.6, Controls (TSRs), must be deleted and replaced with the following:

"The Cs IX hydrogen mitigation system must be operable whenever the Cs IX columns contain ^{137}Cs-bearing waste and/or ^{137}Cs loaded onto the resin in curie amounts that could result in an unsafe accumulation of hydrogen."

Evaluation (Acceptable as modified): The reviewers concluded that the above additions (as modified) are acceptable because they are consistent with the new safety classification of the hydrogen mitigation system evaluated in Section C.1 of this SER, and they adequately describe how the Cs IX Hydrogen Mitigation System will perform its safety function to prevent a potential deflagration or detonation. See COA Nos. 1 through 4 for issues that may impact the ability of the Cs IX Hydrogen Mitigation System to perform its safety function.

4.4.17 Emergency Elution

4.4.17.1 Credited Safety Function

The credited safety function of the Cs IX emergency elution system is to maintain the column at a liquid level that prevents resin heat up to the point of thermal degradation or auto ignition.

4.4.17.2 System Description

The IX columns remove Cs from the waste stream to be processed in the LAW vitrification facility. Cs decay heat is normally removed by flowing liquid through the columns. Should a highly loaded column lose liquid or dry out over an extended time frame, the resin media may overheat. Heat transfer in the resin bed of a dry column will be compromised due to the presence of insulating "dead" air in the void spaces between the resin particles. If the centerline temperature of the resin is elevated, it is possible that the organic resin may thermally degrade (pyrolyze) or autoignite.

The Cs IX emergency elution system will ensure that the required column temperature limits will not be exceeded under column leak, idle, or loss of liquid level control (blowout) conditions. The system includes

- Column resin bed temperature monitoring instrumentation
- Emergency elution system interlock
- Emergency elution system (including vessels, piping, valves, instrumentation)
- Column isolation valve interlock
- Column feed pump valve interlock

4.4.17.3 Functional Requirements

To ensure that the Cs IX column emergency elution system performs its credited safety function, the following functional requirements must be met:

- On detection of high temperature in the column resin bed, the resin bed temperature interlock must:
  - Initiate the emergency elution system
  - Close the column inlet and outlet valves, or close the IX column feed pump suction and discharge valves.
- The emergency elution system vessels, piping, and valves must provide an open flow path to the resin bed for caustic solution, demineralized water, and elution acid.
- The system must be provided with UPS power as necessary to perform its safety function upon a loss of normal power.

The Cs IX emergency elution system has a seismic safety function, is designated SC-III, and constructed in accordance with ISA S84.01, SRD Safety Criteria 4.1-2 through 4.1-4, 4.3-1, 4.3-3, 4.3-4, 4.3-6, 4.4-1, 4.4-2 , and 4.4-6.

4.4.17.4 Standards

The following standards apply to the Cs IX emergency elution system:

- The emergency elution control system will be designed and constructed in accordance with ISA S7.0.01-1996, IEEE 323, IEEE 338, IEEE 384, and IEEE 1023.
- The piping and inline components will be designed and constructed in accordance with ASME B31.3.
- Fabrication materials will be specified in accordance with the applicable ASTM standard, and will be qualified to withstand the environmental conditions for the design life of the component.

4.4.17.5 System Evaluation

The Cs IX temperature instrumentation and controls interlocks will be designed using the cited standards to ensure the reliability of the safety system to perform the necessary functions of detecting high resin temperature. This instrumentation will initiate the emergency elution system to elute the resin of Cs.

The interlocks will shut the column inlet, or close the column feed pump isolation valves. The temperature instrumentation and control system interlocks will protect resin, potentially loaded with Cs, from heating to the point of thermal degradation or auto ignition. The UPS power is designed to the cited IEEE standards to ensure the reliability of the level instrumentation detection system.

4.4.17.6 Controls (TSRs)

The Cs IX column liquid level protection system must be operable whenever the Cs IX columns contain Cs-bearing waste. Surveillances will be required to maintain the reliability of this SSC. The UPS will also require surveillances to verify its operability. Equipment used in the surveillances will be controlled by a measurement and test equipment program addressed as an administrative control in the TSRs.

Required Modifications: For clarity and completeness, the text under Section 4.4.17.1, Credited Safety Function, must be deleted and replaced with the following:

"The credited safety function of the Cs IX emergency elution system is to elute Cs-137 from a column when the level of liquid in the column and Cs-137 loading could cause resin to heat up to the point of thermal degradation or auto ignition when the normal elution system is not available or functional."

For clarity and completeness, the text associated with the second, fourth and fifth bullets under Section 4.4.17.2, System Description, must be deleted and replaced with the following:

- *"Emergency elution system interlock with high resin bed temperature*
- *Isolation valve interlock with high resin bed temperature*
- *Column feed pump valve interlock with high resin bed temperature"*

For clarity, the last sentence under Section 4.4.17.3, Functional Requirements, must be deleted and replaced with the following:

"The Cs IX emergency elution system is designated SC-III, and constructed in accordance with ISA S84.01, SRD Safety Criteria 4.1-2 through 4.1-4, 4.3-1, 4.3-3, 4.3-4, 4.3-6, 4.4-1, 4.4-2 , and 4.4-6."

For clarity and completeness, the following text must be added:

To the end of Section 4.4.17.3, Functional Requirements; *"The SRD contains a complete listing of applicable safety criteria and the QAM specifies applicable QA requirements."* To the end of Section 4.4.17.4, Standards; *"This is a partial listing of standards. A complete listing of requirements is provided in the SRD."*

To the end of the first paragraph under Section 4.4.17.5, System Evaluation; *"The single failure criterion under IEEE 379 was considered for the SS emergency elution system and found to apply. The resin bed temperature sensors will be redundant to ensure the failure of any one sensor will not compromise the temperature sensing safety function. Also, the LS-4 level sensor credited for controlling the level of gas and liquid in the Cs IX column hydrogen mitigation system provides defense in depth since an indication of gas at this level indicates the potential for the resin to be exposed to gas. The project document, "Design Basis Event – Overheating of Cesium Ion Exchange Media, Sheet No. 13", 24590-PTF-Z0C-W14T-00027, Rev. C, showed that fully loaded resin exposed to gas could auto ignite within 110 hours. Thus, gas sensed at the LS-4 control provides sufficient time for manual intervention to correct the problem and/or initiate emergency elution."*

For clarity and completeness, the first two sentences under Section 4.4.17.6, Controls (TSRs), must be deleted and replaced with the following:

"The Cs IX column emergency elution system, resin bed temperature sensors, column isolation valves, column feed pump valves, and interlocks must be operable whenever the Cs IX columns contain sufficient Cs-137 and other radionuclides to cause the resin to heat up to the point of thermal degradation or auto ignition. Surveillances will be required to maintain the reliability of these SSCs."

Evaluation (Acceptable as modified): The reviewers concluded that the above additions (as modified) are acceptable because they are consistent with the new safety classification of the system evaluated in Section C.1 of this SER, and they provide the technical information necessary to adequately describe how the Cs IX emergency elution system will perform its safety function.

4.4.18 Treated LAW Cs IX Column Feed to CXP-VSL-00026A/B/C Gamma Monitor and Interlock

The inadvertent transfer of out-of-specification treated low-activity waste from the Cs IX columns to CXP-VSL-00026A/B/C potentially could cause direct radiation exposures to PT facility workers above the RES.

4.4.18.1 Credited Safety Function

The credited safety functions of the treated LAW Cs IX column feed gamma monitor and interlock are to prevent the transfer of out-of-specification treated LAW to CXP-VSL-00026A/B/C.

4.4.18.2 System Description

The Cs IX column discharge line gamma monitor interlocked to the isolation valves will be used to monitor transfers from the treated Cs IX columns to the CXP-VSL-00026A/B/C. Monitoring the gamma levels will ensure that high dose rate material will not be transferred to CXP-VSL-00026A/B/C.

4.4.18.3 Functional Requirements

To ensure that the Cs IX column discharge gamma monitor interlock performs the credited safety functions, the following functional requirements must be met:

- The gamma monitor interlock must reliably prevent a transfer of out-of-specification treated low-activity feed to CXP-VSL-00026A/B/C.
- The monitor must also alarm the control room and locally to alert PT facility workers that there is high dose rate material in this particular feed line.
- The interlocks must be provided with UPS electrical power as necessary to perform their safety functions.

The gamma monitor and interlocks will be SC-III and designed to meet SRD Safety Criteria 4.1-2, through 4.1-4, 4.3-1, 4.3-3, 4.3-4, 4.3-6, 4.4-1,4.4-2.

4.4.18.4 Standards

The gamma monitor and interlocks will be designed and constructed in accordance with ISA S84.01, IEEE 338, IEEE 384, and IEEE 1023.

4.4.18.5 System Evaluation

The functional requirements of the gamma monitor and interlock is to prevent a transfer of out-of-specification feed to CXP-VSL-00026A/B/C. The gamma monitor alarm alerts PT workers to high level wastes within the Cs IX column feed line. The performance requirements are to design the system to monitor, alarm, and initiate termination of the inadvertent transfer of wastes to CXP-VSL-00026A/B/C. The performance criteria are met by designing the system to ISA S84.01 and the IEEE standards.

4.4.18.6 Controls (TSRs)

The gamma monitor and interlocks are necessary to ensure that out of specification is not transferred to areas that would result in the facility workers being exposed to unacceptable levels of direct radiation. Surveillances will be required to maintain the reliability of these SSCs. Equipment used in the surveillances will be controlled by a measurement and test equipment program addressed as an administrative control in the TSRs.

Required Modifications: For clarity and completeness, the text in the second and third bullets under Section 4.4.18.3, Functional Requirements, must be deleted and replaced with the following. (Note: The replacement text for the third bullet may be deleted upon completion of COA No. 6 in Section Dof this SER.)

- *"The monitor must also alarm the control room and locally to alert PT facility workers that there is high dose rate material in this particular feed line and failure of the isolation valve or actuator, or its inadvertent opening, could result in unsafe radiation levels in related work areas.*
- *The gamma monitor, isolation valve, valve actuator, interlock, and alarms must be provided with UPS electrical power as necessary to perform their safety functions."*

For clarity and completeness, the following text must be added:

To the end of Section 4.4.18.3, Functional Requirements; *"The SRD contains a complete listing of applicable safety criteria and the QAM specifies applicable QA requirements."*
To the end of Section 4.4.18.4, Standards; *"This is a partial listing of standards. A complete listing of requirements is provided in the SRD."*

For clarity and completeness, the text under Section 4.4.18.5, System Evaluation, must be deleted and replaced with the following:

"The functional requirement of the gamma monitor, interlock, and isolation valve and actuator is to prevent a transfer of out-of-specification, highly radioactive feed to CXP-VSL-00026A/B/C. The gamma monitor alarm alerts facility workers to highly radioactive wastes within the Cs IX column discharge line to CXP-VSL-00026A/B/C. The performance requirements are to design the system to monitor, alarm, and terminate the inadvertent transfer of highly radioactive wastes to CXP-VSL-00026A/B/C. The performance criteria are met by designing the system to ISA S84.01 and the IEEE standards listed above and other SRD requirements."

For clarity and completeness, the first sentence under Section 4.4.18.6, Controls (TSRs), must be deleted and replaced with the following:

"The gamma monitor, interlock, and isolation valve and actuator are necessary to ensure that out-of-specification highly radioactive waste is not transferred to areas that would result in the exposure of facility workers to unacceptable levels of direct radiation."

Evaluation (Acceptable as modified): The reviewers concluded that the above additions (as modified) are acceptable because they describe an adequate safety function and controls to protect facility workers against inadvertent exposure to high levels of direct radiation.

5.3.2.2 Cesium Ion Exchange Process (CXP) and Cesium Nitric Acid Recovery Process (CNP) Systems

The cesium ion exchange process system is SS and the cesium nitric acid recovery process system~~s~~ ~~are~~ is SDC. There are no controls for these SSCs because their safety function is passive and managed by the configuration control process. These SSCs must be designed such that the cesium ion exchange ~~column~~ resin bed is not ~~susceptible~~ exposed to low liquid levels or high nitric acid additions.

5.3.2.3 Pretreatment Vessels, Evaporator Separators, and Cs IX Columns

The pretreatment SDC vessels, evaporator separators, and SS Cs IX columns are in sections 4.3.3, 4.4.14, and 4.3.18~~ are SDC SSCs~~. There are no controls for these SSCs because they are passive and their safety function is managed by the configuration control process. These SSCs provide primary confinement of process fluids under normal, abnormal, and accident conditions.

5.3.2.4 Process Vessel Cooling Jackets and~~,~~ Evaporator Separator Reboilers~~, and Cs IX Feed Coolers~~

The process vessel cooling jackets, evaporator separator reboilers~~, and Cs IX feed coolers~~ identified in section 4.3.6 are SDC SSCs. There are no controls for these SSCs because they are passive and their safety function is managed by the configuration control process. These SSCs provide primary confinement of process fluids under normal, abnormal, and accident conditions to prevent contamination of the cooling water system.

> Evaluation (Acceptable): The reviewers concluded that the above deletions and additions in the above Section 5.3.2 subsections are consistent with the new safety classifications for the Cs IX columns and the feed coolers as evaluated in Section C.1 of this SER.

5.5.6 Limiting Condition for Operation - Hydrogen Mitigation Purge and Mixing Systems Operability

Hydrogen concentrations are maintained below the LFL by two methods: headspace air purge for those vessels~~ and cesium ion exchange (Cs IX) columns~~ identified in section 4.3.3 as requiring purging and waste solids agitation for those vessels and evaporator separator vessels identified in section 4.3.3 that require mixing. The headspace air purge sweeps the hydrogen out of the headspace of vessels ~~and the Cs IX columns~~ and exhausts through the vessel vent system. PJMs agitate waste solids in the high solids vessels.

For those vessels and the Cs IX siphon break identified in section 4.3.3 and 4.4.16 as requiring purging, the following additional TSR operability requirements apply:

- The headspace purge systems shall have power from the PT facility SDC electrical system.
- The headspace purge flow monitoring and control system instrumentation shall be operable, providing a remote alarm in the PT facility control room.
- The FEP and CNP evaporator separator reboiler steam flow monitoring systems and interlocks shall be operable, activating the hydrogen purge system when steam flow to a reboiler is lost and vessel liquids are above a specified level.

Derivation Criteria. This control was selected to prevent a hydrogen deflagration in the vessels, evaporator separator vessels, ~~and IX columns~~Cs IX siphon break identified in section 4.3.3 and 4.4.16.

> Required Modifications: For clarity and completeness, this section must be deleted and replaced with the following:

"5.5.6 Limiting Condition for Operation - Hydrogen Mitigation System and Purge & Mixing Systems Operability

Purpose: *This control is based on section 3.4.1.8, Hydrogen Explosion Accident, and section 3.4.2.1, Design Basis Seismic Event. The control ensures operability of the hydrogen mitigation systems, including vessel purge and waste mixing systems, the Cs IX hydrogen mitigation system, and the Cs IX hydrogen mitigation system's siphon break. Without controls, a hydrogen deflagration or detonation could occur. The hydrogen mitigation vessel purge and mixing systems, including the siphon break purge system, maintain hydrogen concentrations in the vessel and siphon break headspace below 25 % of the lower flammability limit (LFL) during normal operations, and below 100 % of the LFL under accident conditions. The oxidant content of the gas collected in the Cs IX hydrogen mitigation system's collection piping is maintained below the lower oxidant concentration (LOC) for an explosion.*

Hydrogen concentrations are maintained below the LFL or LOC by three methods: (1) headspace air purging for those vessels (including the siphon break) identified in section 4.3.3 as requiring purging, (2) waste agitation for those vessels and evaporator separator vessels identified in section 4.3.3 that require waste mixing, and (3) nitrogen-gas inerting for the Cs IX hydrogen mitigation system's collection piping. To prevent hydrogen explosion in a vessel or siphon break due to a loss of power event at the HLW, the hydrogen purge and waste mixing systems at the HLW facility require an SDC air supply. This SDC air supply is provided by the PT facility. In addition, the SDC air compressor also is required to support operability of HLW facility systems as part of a TSR interface requirement. The headspace air purge sweeps the hydrogen out of the headspace of vessels and the Cs IX siphon break and exhausts the gas through the vessel vent system. PJMs agitate waste solids in the high solids vessels; the exhaust air from this agitation method also is exhausted through the vessel vent system.

Nitrogen is supplied to the Cs IX hydrogen mitigation system's collection piping through gas bottles located inside the PT facility. The nitrogen-inerted gas in the Cs IX hydrogen mitigation system's collection piping is expelled under pressure and weak caustic flushing to the siphon break where it is diluted with purge air and exhausted through the vessel vent system. Hydrogen produced in the FEP and CNP evaporator separator vessels is purged by water vapor produced during normal operation, and the FEP separator solids are suspended by the waste feed evaporator recirculation pump. These functions are backed by ITS evaporator separator vessel air purge interlocks for activating the ITS purge air supply when water vapor is not being produced. The air purges, PJMs, and FEP separator drain piping isolation valves have safety instrument control systems that control the supply and flow of air to them. These SSCs require air to operate properly.

The TSR operability requirements for the hydrogen mitigation systems include the following elements:

- *One SDC air compressor shall be operable to supply air to the hydrogen purge system and to the mixing and control system for the PJMs (both at the PT facility and the HLW facility) and the FEP drain isolation valves.*

- *Pressure instrumentation in the air supply system shall be operable, and signal a startup of the ITS air compressors when low pressure is sensed.*
- *The air-supply portions to the vessel and siphon break headspace purge mixing system and the mixing and control system (including valving and receipt tanks) shall be operating to provide (1) supply air to the headspace air purge system to sweep the headspace of hydrogen, (2) supply and control air to PJMs for each applicable vessel, and (3) supply and control air to the ITS air-operated valves.*
- *For those vessels and the siphon break identified in Section 4.3.3 as requiring purging, the following additional TSR operability requirements apply: (1) the headspace purge systems shall have power from the PT facility SDC electrical system, and (2) the headspace purge flow monitoring and control system instrumentation shall be operable, providing a remote alarm in the PT facility control room.*
- *The FEP and CNP evaporator separator reboiler steam flow monitoring systems and interlocks shall be operable, activating the hydrogen purge system when steam flow to a reboiler is lost and vessel liquids are above a specified level.*
- *For those vessels and evaporators identified in section 4.3.3 as requiring solids mixing, the following additional TSR operability requirements apply: (1) the mixing and control system monitoring instrumentation and alarm shall be operable, providing a remote alarm in the PT facility control room when mixing is lost, (2) the FEP evaporator separator recirculation pump power supply monitoring system shall be operable, providing a signal to the control system to activate the timing clock, and using input from vessel level, activate the interlock for opening the drain valves following a specified wait time, and (3) the mixing control, vessel level monitoring, and FEP separator drain valve control systems shall have power from the PT facility SDC UPS system.*
- *The Cs IX hydrogen mitgation system, including LS-1 and LS-4 functions, nitrogen-inerting system, valves and actuators designated as V-1, V-2, and V-3, interlocks to shut off the Cs IX feed pump and open V-1, V-2, and V-3 on sensing gas at LS-4, and control room alarms shall be operable whenever the affected column contains resin and acidic liquids, or uneluted resin or untreated LAW with sufficient Cs-137 and other radionuclides to produce an unsafe accumulation of hydrogen.*
- *The alternate gas flow path from the column (through V-2) shall not be restricted by any means other than by closing V-2.*
- *The total radioactive burden in a single resin column shall be limited to the radiolytic gas generation rate equivalent of 150,000 curies of Cs-137.*

Surveillances related to this LCO include the following elements:

- *Periodic functional tests of the headspace purge and mixing systems, and control systems (including verification that the air supply and control system, and PJMs are operable)*
- *Periodic functional tests of the ITS air-operated valves and control systems (including verification that the air supply is operable)*
- *Periodic functional tests of the air supply system pressure instrumentation (including a verification that the SDC air compressor is operable and will start when low air supply system pressure is sensed)*
- *Periodic functional tests of the headspace purge mixing system and the mixing and control system monitoring and control instrumentation and alarm*

- *Periodic instrument loop calibrations of the headspace purge flow monitoring instrumentation*
- *Periodic instrument loop calibrations of the mixing and control system monitoring instrumentation*
- *Periodic instrument loop calibrations of the evaporator reboiler steam flow and vessel level monitoring system and interlock instrumentation*
- *Periodic instrument loop calibrations of the FEP recirculation pump power supply and vessel level monitoring system and interlock instrumentation*
- *Periodic calibration of the air supply system pressure instrumentation*
- *Periodic instrument loop calibrations and functional tests of the CXP hydrogen mitigation system.*
- *Periodic calibration of the nitrogen supply system pressure and flow instrumentation*

SDC power and SDC air compressors must meet operability requirements. For PT facility SDC power systems, these are covered in a separate LCO. For the diesel systems, they are covered in the BOF PSAR and TSRs.

The TSR and surveillance controls apply to the PT facility in all modes.

Derivation Criteria. *This control was selected to prevent a hydrogen deflagration or detonation in the vessels, evaporator separator vessels, and Cs IX column collection piping and siphon break as identified in Section 4.3.3.*

Evaluation (Acceptable as modified): The reviewers concluded that the above deletions and additions (as modified) are consistent with the safe operation of new Cs IX hydrogen mitigation system, which the reviewers found acceptable (pending successful closure of COAs Nos. 1 through 4 in Section Dof this SER) because the system is designed to "prevent a potential deflagration or detonation" as described in the proposed revisions to Sections 4.4.16 of the PSAR.

5.5.7 Limiting Condition for Operation -Chilled Water Expansion Tank Level Detection Instrumentation and Alarms Operability

Purpose: This control ensures the operability of the chilled water expansion tank level detection instrumentation and alarm. The chilled water expansion tank level detection and alarm instrumentation is used to alert operations personnel when the expansion tank level becomes low so that corrective action can be taken. In this way, the control helps ensure that the expansion tank level remains sufficiently high to maintain chilled water system pressure greater than the pressures within the vessels it cools. This prevents contamination of the chilled water piping in the event of vessel cooling jacket~~ or Cs IX feed cooler~~ leakage. Without controls, chilled water could become contaminated and result in exposures to the facility worker above the RES.

Evaluation (Acceptable): The reviewers agreed that the deletion is consistent with the requirement in the proposed revisions to Section 4.4.15.3 of the PSAR that the components of the feed cooler must maintain their structural integrity and withstand the high radiation environment, the corrosive effects of the process streams, and the erosive nature of the suspended solids. This requirement prevents potential contamination of the chilled water piping.

5.5.9 Limiting Condition for Operation - Cesium Ion Exchange Column ~~Liquid Level~~Temperature Indication ~~Protection Systems Operability~~

Purpose. This control, based on section 3.4.1.7, Cesium Ion Exchange Column Events, and section 3.4.2.1, Seismic Event, ensures operability of the Cs IX column liquid level protection system.

~~A~~ The Cs IX column ~~liquid level detection system and a column resin bed temperature monitoring system initiate~~ resin bed temperature monitoring system initiates the following interlock function~~s~~ on detecting ~~low liquid level or~~ high temperature in the resin bed:

- ~~On initiation of the emergency elution system, the fresh resin addition valve at the outlet of CRP-VSL-00001 must close.~~

~~The Cs fresh resin air gap vessel level detection will indicate that elution reagents are reaching the IX columns.~~

~~The low liquid level detection system interlock also will initiate a reduction in column pressure by the hydrogen purge control system.~~

~~Without controls, t~~ The potential exists for the pressurized purge air system to blow the liquid out of the lead IX column, causing resin dryout, overheat, and potential fire. This can result in exposures to the facility worker, co-located worker, and public receptor above the RES.

The Cs IX column ~~level protection systems~~temperature indication TSR operability requirements include the following elements:

- ~~The column liquid level detection instrumentation shall be operable, detecting column liquid levels below a predetermined value.~~
- ~~The Cs fresh resin air gap vessel level detection system shall be operable, indicating elution reagents are reaching the IX columns.~~
- ~~The fresh resin addition outlet valve and interlock shall be operable.~~
- ~~The column hydrogen purge control system interlock shall be operable, reducing column pressure upon receiving a signal from the level detection instrumentation.~~
- T~~he level detection and interlock components shall be provided power from a PT facility SDC UPS.~~

Surveillances related to this LCO include the following elements:

- ~~Periodic functional tests of the fresh resin addition outlet valve and interlock.~~
- ~~Periodic functional tests of the column hydrogen purge system low pressure interlock~~

Required Modifications: For clarity and completeness, this section must be deleted and replaced with the following:

"5.5.9 Limiting Condition for Operation - Cesium Ion Exchange Column Resin Bed Temperature Control and Emergency Elution System Operability

Purpose. *This control, based on section 3.4.1.7, Cesium Ion Exchange Column Events, and section 3.4.2.1, Seismic Event, ensures operability of the Cesium Ion Exchange Column Resin Bed Temperature Control and Emergency Elution System*

The TSR operability requirements for the Cs IX Column Resin Bed Temperature Control and Emergency Elution System include the following elements:

- *The column resin bed temperature sensing instrumentation and emergency elution system shall be operable whenever the IX column is in service, detecting column resin temperatures over the design-bounding range that includes the temperatures at which operator response is required and the temperature at which emergency elution is automatically initiated.*
- *The inlet and outlet isolation valve, valve actuator, and valve interlocks shall be operable, moving the valves to the proper position upon receiving a signal from the temperature sensing instrumentation.*
- *The Cs IX feed pump shutdown interlock shall be operable, tripping the pump upon receiving a signal from the temperature sensing instrumentation and alarming in the control room.*
- *The LS-1 and LS-4 hydrogen mitigation level controls shall be operable whenever the affected column contains uneluted resin or untreated LAW feed with sufficient Cs-137 that the resin could heat up to the point of auto ignition if the resin becomes dry.*
- *The automatic emergency elution interlock shall be operable and capable of adding and removing a caustic solution, demineralized water, and nitric acid to the column in sequential order upon receiving a signal from the sensing instrumentation.*
- *Minimum levels shall be maintained in the caustic solution, demineralized water, and nitric acid reagent tanks to support the automatic emergency elution system.*
- *The total radioactive burden in a single resin column shall be limited to the thermal equivalent of 150,000 curies of Cs-137.*
- *The alternate gas flow path from the column (through V-2) shall not be restricted by any means other than by closing V-2.*

Surveillances related to this LCO include the following elements:

- *Periodic verification that sufficient levels exist in the reagent head tanks to perform emergency elution*
- *Periodic functional tests of the emergency elution interlock, the inlet and outlet isolation valve interlocks, the Cs IX feed pump shutdown interlock, and control room alarm*
- *Periodic instrument loop calibrations of the level detection and temperature monitoring instrumentation*

Operability requirements and surveillances on the PT facility SDC UPS power are required, and are covered in a separate LCO in Section 5.5.14.

Evaluation (Conditionally acceptable as modified): The reviewers concluded that the deletions and additions (as modified) are consistent with the safe operation of the emergency elution system as described in the modified Section 4.4.17 of the PSAR and found acceptable in the reviewers' evaluation because the system prevents resin heat up to the point of thermal degradation or auto ignition. The reviewers also found the following proposed deletion from the former revision of Section 5.5.9 acceptable, *"The level detection and interlock components shall be provided power from a PT facility SDC UPS"* given the Contractor satisfies Condition of Acceptance No. 6 in Section D of this SER.

~~5.5.19 Limiting Condition for Operation -Cs IX Feed Cooler Chilled Water Pressure Monitoring Instrumentation and Interlock Operability~~

~~**Purpose:** This control, based on protecting facility workers from a loss of contamination control accident, ensures the operability of the Cs IX feed cooler chilled water pressure monitoring instrumentation and interlocks. The chilled water pressure monitoring instrumentation and interlocks are used to shut down the Cs IX feed pumps on detecting low chilled water pressure. Low pressure in the chilled water system and a breakthrough in the barrier between the process and cooling sides of the Cs IX feed coolers could allow radioactive process materials to circulate in the chilled water system and pose a radiological hazard to facility workers.~~

~~The TSR operability requirements for the Cs IX feed cooler chilled water pressure monitoring instrumentation and interlocks include the following elements:~~

- ~~The chilled water pressure monitoring instrumentation and interlocks shall be operable, initiating shutdown of the Cs IX feed pumps (CXP-PMP-00001A/B) when pressure levels fall below a predetermined value.~~
- ~~The Cs IX feed pumps (CXP-PMP-00001A/B) controls shall be operable, shutting the pumps down upon receiving a signal from the chilled water pressure monitoring instrumentation and interlocks.~~
- ~~The Cs IX feed cooler chilled water pressure monitoring instrumentation and interlocks shall have power from the PT facility SDC UPS system.~~

~~Surveillances related to this LCO include the following elements:~~

- ~~Periodic calibration and functional tests of the pressure monitoring instrumentation~~
- ~~Periodic functional tests of the chilled water pressure interlocks~~

~~Operability requirements and surveillances on the PT facility SDC UPS power are required, and are covered in a separate LCO.~~

~~These controls apply to the PT facility in all modes.~~

~~**Derivation Criteria:** This control was selected to prevent unacceptable radiological exposures to facility workers.~~

Evaluation (Acceptable): The reviewers concluded that the above deletions are acceptable because the Cs IX feed cooler pressure monitoring and interlock system is no longer credited as a control for the chilled water system as evaluated in Section C.1 of this SER.

5.5.X Limiting Condition for Operation - Treated LAW Cs IX Column Feed to CXP-VSL-00026A/B/C Gamma Monitor and Interlock Operability

Purpose: This control is necessary to protect a TSR interface with CXP-VSL-00026A/B/C and to protect PT facility workers. The control ensures the operability of the Cs IX feed line gamma monitor and interlock. The gamma monitor and interlock prevent the inadvertent transfer of out-of-specification treated low-activity waste to CXP-VSL-00026A/B/C. Without controls, PT facility workers could be exposed to high radiation, resulting in exposures above the RES.

The TSR operability requirements for the Cs IX feed line gamma monitor and interlocks include the following elements:

- The gamma detection and alarm instrumentation shall be operable
- The gamma monitor interlock shall be operable
- The Cs IX transfer piping isolation valve actuation equipment shall be operable, to prevent transfer to CXP-VSL-00026A/B/C when an unacceptable gamma source is present
- The Cs IX transfer valve actuation equipment shall be operable, to prevent high dose rate wastes from being transferred from the Cs IX columns and to CXP-VSL-00026A/B/C

Surveillances related to this LCO include the following elements:

- Periodic functional tests of the gamma monitor, alarm, and interlocks
- Periodic verification that the Cs IX transfer piping isolation valve actuation equipment is operable
- Periodic verification that the Cs IX transfer valve actuation equipment is operable

These controls apply to the PT facility in the operation mode. As mode definitions are further refined as part of the FSAR effort, it is expected that the applicability of this control to the Cs IX column feed line gamma monitor and interlocks will be limited to those modes where material transfers to the Cs IX columns could expose workers in C3 areas are possible.

Derivation Criteria: This control also prevents the PT facility worker from receiving unacceptable direct radiation consequences.

Required Modifications: For clarity and completeness, this section must be deleted and replaced with the following:

"5.5.X Limiting Condition for Operation - Treated LAW Cs IX Column Feed to CXP-VSL-00026A/B/C Gamma Monitor and Interlock Operability

Purpose: *This control is necessary to protect a TSR interface with CXP-VSL-00026A/B/C and to protect PT facility workers. The control ensures the operability of the Cs IX feed line gamma monitor and interlock. The gamma monitor and interlock prevent the inadvertent transfer of out-of-specification highly radioactive waste to CXP-VSL-00026A/B/C.*

The TSR operability requirements for the Cs IX feed line gamma monitor and interlock system include the following element:

- *The gamma detection instrumentation, isolation valve, valve actuator, valve interlock, and local and control room alarms shall be operable to prevent the transfer of highly radioactive wastes to CXP-VSL-00026A/B/C and to warn operators of the risk of radiation exposure.*

Surveillances related to this LCO include the following element:

- *The functionality of the gamma detection instrumentation, isolation valve, valve actuator, valve interlock, and local and control room alarms shall be verified periodically.*

These controls apply to the operation mode. As mode definitions are further refined, the applicability of these controls will be limited to those modes in which transfers of waste to CXP-VSL-00026A/B/C that could expose workers to unsafe levels of direct radiation are possible.

Derivation Criteria: *This control prevents the PT facility worker from receiving unacceptable direct radiation exposures.*

Evaluation (Acceptable as modified): The reviewers concluded that the revised additions describe operability controls that are adequate to prevent unacceptable radiation doses to facility workers in the vicinity of piping associated with vessels that have the potential to receive inadequately treated LAW from the IX columns.

Derivation Criteria: The ion exchange column hydrogen generation rates are based on this loading (150,000 Ci Cs-137). ~~purge air flowrate will be set at a minimum of 100 times the maximum hydrogen generation rate calculated for the column.~~ The calculation to determine the maximum hydrogen generation rate is in development. The resin bed loading limit and the column flow rate controls will maintain the safety envelope of the column within analyzed boundaries.

Evaluation (Unacceptable): The reviewers concluded that this text has no relevance to the preceding text and must be deleted or relocated to where relevant.

5.6.8 Cesium Ion Exchange Column ~~Liquid Level~~

Design features for the Cs IX column ~~liquid level~~ protection system include the following:

- The redundant collected hydrogen purge exhaust system must maintain an open flow path.

Evaluation (Unacceptable): The reviewers concluded that this text is not relevant to the Cs IX column, but is to Section 5.5.6, Limiting Condition for Operation - Hydrogen Mitigation Systems Operability and to Section 5.5.9, Limiting Condition for Operation - Cesium Ion Exchange Column Resin Bed Temperature and Emergency Elution System Operability, where revised versions of this requirement are found. Therefore, this section must be deleted.

5.6.9 Cs Ion Exchange Process (CXP) and Cs Nitric Acid Recovery Process (CNP) Systems

Design features for the cesium ion exchange process and cesium nitric acid recovery process systems include the following:

- ~~The hydraulic design of the Cs IX column and associated upstream and downstream vessels must prevent the liquid level from dropping below the column inlet diffuser under static conditions, to protect against uncovering the resin bed.~~

Required Modifications: For clarity and completeness, the deleted text must be replaced with the following:

- *"The hydraulic design of the Cs IX column and associated upstream and downstream piping must enable the resin bed to be submerged in liquid at all times to protect against a potential fire."*

Evaluation (Acceptable as modified): The reviewers concluded the deleted text was still relevant as revised since this requirement, which ensures the column remains fully flooded under all conditions when resin is in the column, thereby preventing a resin fire, was not covered elsewhere in the TSRs.

Note: The Contractor's red-line/strikeout changes could not be imported from the following tables. The final changes are shown underlined in yellow highlight. Although deletions to these tables are not shown, they are discussed in the reviewers' evaluation.

Table 3A-4 Process Chemicals

Material	**Plant Item No.**	**Purpose**
Nitrogen	Nitrogen rack (TBD)	Cs IX hydrogen mitigation inerting gas.

Evaluation (Acceptable): In Table 3A-4, the reviewers agreed that nitrogen is added to the modified hydrogen mitigation system as the hydrogen inerting agent.

Table 3A-5 Hazardous Characteristics of PT Chemicals

		EHS Indicators					
Chemicals[a]	**Form**	**EPA[b]**	**ERPG/TEEL[c] mg/m[c] (ppm)**	**NFPA[d]**	**Acute Toxic**	**Flammable /Explosive**	**Reactive**
Antifoam	Liquid	No	--	1/1/0	Inhalation: No injury is likely. Eye: mild irritation. Skin: No adverse effect. Ingestion: Large amounts may cause discomfort.	Not flammable, combustible or explosive.	Stable. Oxidizing material may cause reaction.

Table 3A-5 Hazardous Characteristics of PT Chemicals

Chemicals[a]	Form	EHS Indicators			Acute Toxic	Flammable /Explosive	Reactive
		EPA[b]	ERPG/TEEL[c] mg/m[c] (ppm)	NFPA[d]			
Nitrogen	Gas	No	--	--	Nitrogen is an asphyxiant, not a toxic chemical.	Not flammable, combustible or explosive.	Nitrogen in inert.

Evaluation (Acceptable): In Table 3A-5, the reviewers agreed that nitrogen added to the modified hydrogen mitigation system as the hydrogen inerting agent is an asphyxiant.

Table 3A-6 PT Chemical Interactions Matrix

Materials	Sodium Hydroxide	Nitric Acid	Sodium Nitrite	Sodium Permanganate	Strontium Nitrate	SuperLig 644	Antifoam
Nitrogen gas	NR	NR	NR	NR	NR	NR	NR

NR - No reaction
CR - Heat generation by chemical reaction, may cause pressurization if not vented.
Reacts; dec. = decomposes.
Rx - Reacts to high concentrations of nitric acid, lower concentrations are used to elute cesium.
Source: 24590-WTP-RPT-ESH-01-001

Evaluation (Acceptable): In Table 3A-6, the reviewers agreed that nitrogen added to the modified hydrogen mitigation system as the hydrogen inerting agent is unreactive with other process materials.

Table 3A-7 PT Energy Sources

Energy	Energy Type	Source/Quantity
Potential	Pressure fluids Air/Nitrogen	Pressurized feedlines, process water lines, pressurized resin flushes and transfer, dewatering lines, transfer lines, pressurized slurry feed lines, supply tanks and distribution piping.

Evaluation (Acceptable): In Table 3A-7, the reviewers agreed that nitrogen added to the modified hydrogen mitigation system as the hydrogen inerting agent is a pressurized energy source.

Table 3A-8 PT Risk Reduction Class Items

SSC	RRC Function

Evaluation (Acceptable): In Table 3A-8, the Contractor deleted reference to an obsolete level monitoring system in the replaced hydrogen mitigation system and to radiation monitoring in the transfer line from the IX columns to RDP VSL 0002A/B/C. The reviewers agree that deletion of the credited radiation monitoring in the transfer line from the IX columns to RDP VSL 0002A/B/C is acceptable because the Contractor reported these vessels are located in a C5 area and are equipped with air purge systems to mitigate hydrogen that would be evolved in the event waste containing high Cs-137 levels was improperly transferred to these vessels. The proposed revisions to the RDP VSL 0002A/B/C control system are documented in CCN 100638 (to be forwarded).

Table 3A-8A PT Additional Protection Class Items

SSC	APC Function
1. CNP nitric acid concentration monitors and interlocks.	Prevent inadvertent transfer of out of specification acid to the IX columns.
2. Emergency elution reagent vessel level monitoring	Ensure minimum volumes of reagents required for emergency elution are available.
3. Cs evaporator separator temperature monitor and interlock.	Prevent over-concentration of nitric acid

Evaluation (Acceptable): In Table 3A-8A, the reviewers agreed the changes are acceptable because the Contractor is adding APC controls to prevent reactions and heating in the IX columns.

Table 3A-13 Seismic Category of PT SDC/SC and SDS/SS SSCs

SSCs	Component Identification	Seismic Category
	Cs IX columns (CXP-IXC-00001/2/3/4)[2]	III
Cs IX Hydrogen Mitigation System	Cs IX Hydrogen mitigation piping, level switches, Nitrogen Supply system[3]	III
IX Feed Coolers	CXP-HX-00001A/B CNP-HX-00001	III
Cs IX Emergency Elution	Cs IX column emergency elution piping and components (Includes NAR, SHR, and DI supply vessels at 98' level).	III
Cs Nitric Acid Recovery Process System	Hydraulic design	I

Evaluation (Acceptable): In Table 3A-13, the reviewers agreed with the seismic designations shown because they are consistent with the seismic safety function designation as defined in Safety Criterion 4.1.3 of the SRD.

Table 4A-1 Important to Safety: Description and Basis for Safety Design Class Structures, Systems, and Components

SDC System (Major Components)	Credited Safety Function	Representative and Bounding Accident (Chapter 3)	Controls (Chapter 5)

Required Modifications: For correctness, the text in the fifth row under "Controls (Chapter 5)" in the original table must be deleted and replaced with the following:

"Design features – PT vessels and evaporator separators, 5.6.10"

[2] Although classified as SC_III as a result of DOE-STD-3009 implementation, the Cs IX columns (CXP-IXC-00001/2/3/4) are designed and being procured as Seismic Category I (SC-1).
[3] Level Switches #2 & #3 of the hydrogen mitigation system are CM/SC-IV. The Nitrogen Supply system piping from the hydrogen mitigation system bulge up to and including the nitrogen supply tanks are SS/SC-III.

For correctness, the text in the tenth row under "Controls (Chapter 5)" in the original table must be deleted and replaced with the following:

"Design features – Process vessel wall enclosed by cooling jackets and evaporator separator reboiler tubes, 5.6.11"

Evaluation (Acceptable as modified): In Table 4A-1, the Contractor deleted the following credited SDC SSCs: Cs IX feed coolers and pressure interlock, Cs IX liquid level system and interlock, Cs IX automatic elution system, Cs IX column isolation valves, nitric acid concentration monitors and interlocks, CXP system hydraulic design, and Cs evaporator separator temperature monitor and interlock. The Cs IX feed coolers, Cs IX automatic elution system, and CXP column hydraulic design were reclassified as SDS SSCs as shown in Table 4A-2 below. The Cs IX liquid level system and interlock were part of the obsolete hydrogen mitigation system and thus the reviewers found these changes acceptable. The Cs IX feed cooler pressure interlock, Cs IX column isolation valves, nitric acid concentration monitors and interlocks, and Cs evaporator separator temperature monitor and interlock are no longer designated as SDC based on the new safety classification. This was discussed in Section C.1 of this SER.

Table 4A-2 Important to Safety: Description and Basis for Safety Design Significant Structures, Systems, and Components

SDS System (Major components)	**Credited Safety Function**	**Representative and Bounding Accident (Chapter 3)**	**Controls (Chapter 5)**

Table 4A-2A Important to Safety: Description and Basis for Safety Significant (SS) Structures, Systems, and Components

SS System (Major components)	**Credited Safety Function**	**Representative and Bounding Accident (Chapter 3)**	**Controls (Chapter 5)**
Cs IX Columns (H_2 Hazards) (SS) 4.4.14	Provide primary confinement of process materials and to maintain an intact connection with the hydrogen collection piping, and dilution systems.	3.4.1.7, 3.4.2.1	LCO - Cesium ion exchange column level protection systems operability 5.5.9 Design features - Cesium ion exchange column level protection systems 5.6.8
IX Feed Coolers 4.4.15	Provide primary confinement of process liquids, the release of which to service systems could exceed RES to facility workers.	3.3.5.1	Design features - Process vessel cooling jackets, evaporator separator reboilers, and Cs IX feed coolers 5.6.11
Cs IX Hydrogen mitigation system 4.4.16	Cs IX Hydrogen mitigation system is to maintain the column/collection piping to prevent a potential deflagration or detonation.	3.4.1.7, 3.4.2.1	LCO - Cesium ion exchange column level protection systems operability 5.5.9 Design features - Cesium ion exchange column level protection systems

			5.6.8
Emergency Elution 4.4.17	Cs IX emergency elution system is to maintain the column at a liquid level that prevents resin heat up to the point of thermal degradation or auto ignition.	3.4.1.7, 3.4.2.1	LCO - Cesium ion exchange column level protection systems operability 5.5.9 Design features - Cesium ion exchange column level protection systems 5.6.8
Treated LAW Cs IX Column Feed to CXP-VSL-00026A/B/C Gamma Monitor and Interlock	Prevent the transfer of out-of-specification treated LAW to CXP-VSL-00026A/B/C.	3.3.5.1	LCO - Treated LAW concentrate storage vessel gamma monitor interlock operability

Required Modifications: For correctness, the text in the third row under "Controls (Chapter 5)" in the original table must be deleted and replaced with the following:

"LCO – Cs IX column gas collection system and siphon break protection systems operability, 5.5.6"

For correctness, the text in the fourth row under "Controls (Chapter 5)" in the original table must be deleted and replaced with the following:

"LCO – Cs IX column resin bed temperature control and emergency elution system operability, 5.5.9"

Evaluation (Acceptable as modified): In Table 4A-2A, the Contractor added SS SSCs, reflecting the new hydrogen mitigation system and the new safety classification system. The reviewers found these changes acceptable because they are consistent with the new safety classification scheme defined in Appendix A, Section 6.0 of the SRD. This was discussed in Section C.1 of the SER.

Table 5A-1 Hazard and Accident Analysis and Technical Safety Requirement Cross Reference

Chapter 3 Section	Technical Safety Requirement	Control Basis
Facility Worker Safety Results (3.3.5)	LCO - Remote sampling system HEPA filter operability (5.5.5)	Provides secondary confinement for sampling operations
	LCO - Cs IX feed line to CXP-VSL-00026A/B/C gamma monitor interlock operability	Prevent mistransfer of high-level waste to CXP-VSL-00026A/B/C and causing a direct radiation hazard.

Evaluation (Acceptable): The Contractor deleted the LCO for Cs IX feed cooler chilled water pressure monitoring instrumentation and interlock operability. The reviewers found this acceptable because chilled water pressure monitoring instrumentation and interlocks are not credited. This was discussed in SER Section 3.1 The reviewers agreed that an LCO for CXP-VSL-00026A/B/C gamma monitor interlock capability was needed to prevent mistransfer of high radiation waste and subsequent Facility Worker radiation exposure.

D.0 ORP QUESTIONS, SAFETY ISSUES, AND CONDITIONS OF ACCEPTANCE

During the review, the ORP reviewers developed and submitted questions related to the ABAR and its bases to the Contractor. The ORP questions, the Contractor's responses, and ORP's disposition of the responses are listed in Attachment 1. As shown in the questions, the ORP reviewers focused on three significant safety issues that were not addressed fully in the ABAR or in supporting basis documents. These issues include: (1) hydrogen accumulations that may not be mitigated adequately[RT1], (2) hydrogen and oxidant generation uncertainties and their impacts, and (3) reliability of the hydrogen mitigation system. These issues are described below. Seven Conditions of Acceptance (COA) that must be met for approval of the ABAR also are described.

D.1 Hydrogen Accumulations and Releases That May Not Be Adequately Mitigated

The first part of this issue deals with the potential for hydrogen accumulations in various locations outside the Contractor's currently analyzed boundary for accumulations in amounts that may exceed the capacity of the new hydrogen mitigation system, and in other related locations that are not piped to the new hydrogen mitigation system and therefore cannot be mitigated by the new hydrogen mitigation system. These locations, which the Contractor requested be addressed under an existing COA from PSAR Update review (Item 5[d], Section No. 4.2, of *Safety Evaluation for WTP Construction Authorization*, ORP/OSR 2003-22, Rev. 0, with a due date of December 31, 2005), include:

a) high points in the chilled water system used to cool IX column feed
b) sections of the IX column feed piping isolated by automatically closed valves
c) the IX column's feed distributor and associated vertical piping
d) the apex of the piping that connects the lead and lag columns
e) the piping connecting the rupture disc to the column
f) the piping between L1 and the siphon break
g) two dead legs in the hydrogen mitigation system piping

In location (g) above, the Contractor (in its response to question RT-30 shown in Attachment 1 to this SER) agreed to modify the design to ensure the preferential flow of hydrogen would be to the hydrogen mitigation system's collection piping rather than to the dead legs, thereby precluding accumulations in these areas. The Contractor's responses to ORP questions regarding the other locations where accumulations may occur stated that the drawings of the associated components are preliminary, and that once a true representation of the system is issued, a thorough investigation of piping that can trap hydrogen will be initiated. (See the Contractor's responses to questions RT-5., -6, -9, and -10 in Attachment 1 to this SER.) The reviewers considered this response acceptable if the investigation, analysis of the impacts of credible hydrogen accumulations, identification of controls, and changes to the design (if any are needed) will be completed in accordance with existing Condition of Acceptance (COA) (Item 5[d], Section No. 4.2, of *Safety Evaluation for WTP Construction Authorization, ORP/OSR-2003-22, Rev. 0*) as requested by the Contractor. As part of this COA and before installation of impacted components begins, the Contractor must evaluate potential hydrogen accumulations associated with the components shown in the table below. The evaluation must address bounding hazards and identify controls where necessary. Also, the Contractor must modify the design of the hydrogen mitigation system to ensure preferential flow of hydrogen to the hydrogen mitigation system's collection piping rather than to the dead legs (location g above).

CXP and Related System Locations in which Hydrogen Can Accumulate	Conditions Requiring Evaluation
a) High points in the chilled water system	Under static cooling water conditions and when IX column feed remains within the feed coolers
b) Sections of the IX column feed piping isolated by automatically closed valves	When filled with design-basis feed
c) The IX column's feed distributor and associated vertical piping	When the column is loaded with Cs-137 and upon extended loss of feed pumping and automatic closure of isolation valves
d) The apex of the piping that connects the lead and lag columns	When the lead column is fully loaded but stagnant, resulting in radiolysis of the treated waste in the piping located near the fully loaded lead column and leading to the apex
e) The piping connecting the rupture disc to the column	After the column has been placed into radioactive service
f) The piping between L1 and the siphon break during an extended outage	When slow leakage or evaporation may occur, causing the liquid level to drop and confine radiolytic gases

The second part of this issue was that the lack of a control strategy for the hazards associated with slow leakage of nitrogen from the hydrogen mitigation collection system's valves, instruments, and flanges, could result in accumulating an explosive gas mixture within the collection system. The Contractor's previous response to this issue, which showed the specified rate of valve leakage would not create a hazardous condition within the maximum allowable hydrogen accumulation time, was unacceptable to the reviewers because it did not account for potential leakage through flanges or through valve wear. The Contractor must resolve this issue in accordance with COA No. 1 below:

> **COA No. 1:** Within 60 days of ORP's issuance of this SER, describe the control strategy that will prevent an unacceptable rate of displacement of the nitrogen in the hydrogen mitigation collection system through leaks, and creation of a flammable or explosive mixture in the collection system when the rate of leakage in the system approximates the rate of radiolytic and thermolytic gas generation in the IX column.

A third part of this issue was that the design of the hydrogen mitigation collection and inerting system had not considered a bounding instantaneous release of a bubble(s) of gas from the resin and other location within the CXP System when system conditions change from the normal operations case that was the basis for the system design. A relatively large release could occur when the pump stops after a short period of time due to the formation and attachment of hydrogen bubbles to the resin beads, causing a sudden release of the bubbles when the bubble size grows and creates buoyant conditions. The released gas would momentarily accumulate in the collection system before it is released to the siphon break. The Contractor's assumption of a bounding release of a one-liter bubble from the IX column was not supported by analysis or experienced-based data. (See the Contractor's response to question RT-31.) The reviewers also were concerned that the Contractor was unable to define (1) a bubble size and other conditions below which damage to the system was extremely unlikely, and/or (2) a bounding pressure for the deflagration or detonation of a bubble event. See the Contractor's response to question RT-13. The reviewers' concerns arise from knowledge of past deflagration/detonation events in similar systems and the Contractor's acknowledgement in Section 3.4.1.8.4 of the PSAR that "accumulated hydrogen in the column collection system piping can be postulated to be ignited by static discharge, electrical discharge from instruments, or arcing from a lightning strike grounding through a path that includes the IX column." It is unclear how controls to effectively prevent the lightning or static initiators and, therefore the explosion, would be implemented. This issue is addressed as the first part of COA No. 3 below.

The fourth part of this issue was that an allowable time for the column to remain in stand-by (no flow) under loaded conditions had not been determined. Excessive time in standby under loaded conditions could result in a buoyant roll-over of the resin due to accumulated gas bubbles by the same mechanism observed in the "burping" Hanford tank 241-SY-101. Such a rollover appeared to have the potential to exceed the capacity of the hydrogen mitigation system. The bounding hydrogen bubble size and time in standby under loaded conditions that results in a buoyant roll-over of the resin due to accumulated gas bubbles are factors that impact the effectiveness of the hydrogen mitigation system. Section D.2 of this SER addresses these and other factors in COA No. 3. This issue is addressed as the second part of COA No. 3 below.

D.2 Hydrogen and Oxidant Generation Uncertainties and their Impacts

This issue, in part, concerns the modeling of hydrogen generation inside the CXP column. The Contractor used laboratory test data for determining hydrogen generation rates and total gas generation rates for various mixtures to be encountered in the columns (BNI Calculation No. 24590-PTF-MVC-CXP-00015, CXP Ion Exchange Column Gas Generation Rtes, dated June 2004, and 24590-101-TSA-W000-0004-82-03, Rev. B, Report-Radiation Stability Testing of SuperLig 639 and SuperLig 644 Resins, dated January 2003). The mixtures that were tested in the laboratory were LAW/resin, nitric acid/resin, and water/resin at several temperatures and radiation exposures. The tests measured the quantities and compositions of various gases that were generated by thermolysis and radiolysis. These tests were performed with "closed" systems, where it is known that hydrogen generation rates by radiolysis can be lower than for "open" systems. For example, the radiolysis G-value for hydrogen in water was determined to be about 0.2 molecules per 100eV for these tests compared to the generally accepted value of 0.45 molecules per 100eV for an "open" system. Note that hydrogen generation rates are lower in closed systems because radicals that are formed by radiolysis, i.e., [OH], [H], and [O], can recombine to form water. Although the hydrogen mitigation system normally is operated under pressure, the ORP reviewers consider the Cs IX columns to be "open" because liquids and generated gases are continuously removed during operation. The reviewers noted also that the waste simulant used in the laboratory tests did not contain representative quantities of transition and noble metals that are known to be present in the radioactive wastes to be processed in the WTP. These metals can act as catalysts in the oxidation of organic materials. Therefore, the measured gas generation rates may have been lower than would have occurred if these metals had been present in the simulant. Therefore, the reviewers were concerned that the Contractor may be using non-conservative test data for determining the hydrogen and total gas generation rates in the columns.

The reviewers also were concerned that the Contractor was using long-term test radiation exposure data (at 147 hours) compared to short-term test exposure data (at 1.47 hours) that would be more representative of the radiation exposures to be expected per operating cycle in the columns. The laboratory data showed that the total gas generation rates were a factor of 5 to 10 times higher for the short-term tests than for the long-term tests. However, the Contractor responded that hydrogen generation rates were slightly higher for the long-term tests than for the short-term tests. The hydrogen was about 3% of the total gas in the short-term tests and about 20% of the total gases for the long-term tests for the 0.5M nitric acid/resin system at 25 ^{o}C. As the temperature was increased to 65 ^{o}C and to 90 ^{o}C in the long-term tests, the thermolysis of the resin and reaction with nitric acid increased greatly so that hydrogen percentage decreased to only 4% and 0.4%, respectively. Resin decomposition products, CO_2, N_2, and N_2O, dominated the total gas generated. The data on these gases demonstrate the wide variability in the compositions of the gases that may collect in the hydrogen mitigation system.

In its response to question GR-8, the Contractor committed to the following design to assure that explosive gas mixtures are not accumulated in the columns. First, the total gas generated in the columns that are released to the hydrogen mitigation collection system will be diluted with nitrogen at a ratio of at least 4.5 moles nitrogen per mole of total gas generated. This will ensure that the gases collected will not be explosive since the concentration of oxidants will be kept below the limiting oxidant concentration (LOC) of 6%. The reviewers also noted that the basis for setting the LOC at 6% is data for the hydrogen/nitrogen/oxygen system from a Technical Note 3935 issued in 1957 by the National Advisory Committee for Aeronautics, *Hydrogen-Oxygen Explosions in Exhaust Ducting*. A more recent reference, NFPA 69, *Standard on Explosion Prevention Systems*, 2002 Edition, Table C.1 (a), gives an LOC of 5% for this system. However, the reviewers noted that the LOC in both documents is based upon the oxidant being only oxygen. Moreover, the primary oxidant in the gases generated from the laboratory radiolysis/thermolysis tests was nitrous oxide. In these tests, the nitrous oxide concentration ranged from a minimum of about 85% of the total oxidants (nitrous oxide plus oxygen) to nearly 100%. Thus, the reviewers considered that the LOC of the hydrogen/nitrogen/nitrous oxide system was more appropriate as a basis rather than the LOC for the hydrogen/nitrogen/oxygen system unless it can be shown that the LOC for the former system is higher than for the latter. The Contractor must resolve this issue in accordance with COA No. 2 below:

> **COA No. 2:** Within 30 days of ORP's issuance of this SER, determine the LOC for the hydrogen/nitrogen/nitrous oxide system and use this value for the LOC if it is less than the LOC for the hydrogen/nitrogen/oxygen system. Otherwise, use the LOC for the hydrogen/nitrogen/oxygen system of 5% as a basis. Also, provide a justification for not adopting NFPA 69 in its entirety as a standard for preventing explosions. Explain why hydrogen monitoring of the accumulated gas in the collection system is unnecessary. Also address the effects of transition and noble metals on gas generation rates.

As a second feature of the design, which enables the collected gases to be periodically flushed with dilute sodium hydroxide solution, the gas/hydrogen mixture will be expelled into a siphon break that will be provided with an ITS air purge rate that is at least 100 times the maximum calculated total gas generation rate (0.0156 scfm or 0.44 l/m from Table 19 in the reference calculation in the ABAR). This gas generation rate is based on the safety case Cs-137 loading of 150,000 Ci, a maximum temperature of 113 ^{o}F, and the nitric acid/resin system. The hydrogen gas content entering the hydrogen mitigation collection system is expected to be about 6% under these conditions.

The total normal gas generation rate, when loading the column with LAW feed to the safety case limit, is calculated to be 0.00122 scfm, and the hydrogen gas content is about 42%. Thus, even though the total gas generation rate may be underestimated by using the long-term test data rather than the short-term data, by using a waste stimulant that did not contain representative amounts of transition and noble metals, and by considering the mitigation system a “closed” system rather than an “open” system, the reviewers were satisfied that there probably is adequate conservatism with the nitrogen dilution rates to prevent an explosive gas mixture from <u>normally</u> occurring within the collection system. It is important to recognize that the quantity and frequency of nitrogen additions will be based upon actual total gas generation rates in the WTP rather than those calculated from laboratory measurements. Note, however, that a higher gas generation rate may adversely impact the reliability of the hydrogen mitigation system by increasing the valve cycling frequency as discussed in Section 4.3 of this SER. The nitrogen dilution rate design is based upon the highest expected total gas generation rate (0.44 l/min) under safety case conditions, which include 150,000 Ci Cs-137 loading and the highest expected allowable operating temperature [113 ^{o}F] in the nitric acid/resin system. Further consideration of issues associated with relative gas solubility as described below may alter the conclusion that the maximum nitrogen dilution rate is adequate to prevent an explosive gas mixture from <u>normally</u> occurring within the collection system, however. Moreover, the <u>off-normal</u> releases of gas from the resin and waste in the column and elsewhere within the CXP system (see the other locations where hydrogen may accumulate and flow to the IX columns in Section D.1) might cause the capacity of the collection system to be exceeded if the release exceeds the one-liter bubble design basis.

The reviewers also noted that the actual hydrogen concentrations in the gas stream (before dilution with nitrogen) will vary depending upon the resin/solution combination, the temperature, and Cs resin loading. The hydrogen concentration is expected to range from a maximum of about 67% for the LAW/resin system at 25 ^{o}C and 150,000 Ci Cs-137 loading to a minimum of about 6% for the nitric acid/resin system at 45 ^{o}C with the same Cs loading. The collected hydrogen concentration may be higher or lower than these values depending on the relative solubilities of the individual gases in the waste and in the slightly caustic flush solution that normally will be present above the column. The gases will rise through these solutions and be partially solubilized before accumulating in the collection system. Higher relative hydrogen solubility would result in a lower relative concentration in the collected gas, and vice versa. Differing solubilities of the individual gases also may impact the ability to ensure the concentration of oxidants is kept below the 6% design basis of the hydrogen collection system. Although the ITS air purge rate of at least 100 times the maximum calculated total gas generation rate on the surface appears to be adequate to ensure the hydrogen will be diluted to well below its lower flammability limit, the injection of purge air into the siphon break at this rate (<2 scfm) is about equal to the human breathing rate. This slow rate of injection would be insufficient to cause instantaneous mixing and dilution of the rapidly-released hydrogen, especially within the relatively large volume (at least 170 liters) of the siphon break. This would result in slowly mixing the released hydrogen-bearing gas with the air in the siphon break, and might create transitory gas layers in which the hydrogen and oxygen levels are sufficient to support combustion. Exacerbating this issue is the Contractor's assumption that one-liter gas bubbles (and the reviewers’ contention that larger bubbles can form) can periodically be released from the resin and other areas in the CXP System, and accumulate in the collection system with the normally released gas in combined amounts that exceed the collection system's design capacity. The following analysis of the one-liter gas bubble release demonstrates this concern.

If gas containing 67% hydrogen is being generated in the column and the nitrogen volume is nominally 4.5 liters and the nominal volume of collected Cs IX column gas is 1.0 liter, the sudden release of the additional one-liter gas bubble would result in a nitrogen-inerted hydrogen concentration of greater than 20% in the collection chamber. When this gas is released into the siphon break, it will depressurize and expand by a factor of about 5X, resulting in the release of about 33 liters of gas containing 20% hydrogen. Because the siphon break's air purge rate of 100 times the maximum gas generation rate from the column is about the same as the human breathing rate, it will have little immediate effect on diluting the 20% hydrogen stream rapidly released into the air-filled siphon break. Some mixing of the 20% hydrogen stream and the air (21% oxygen) in the siphon break will occur during the release, however, likely resulting in layers of gas that are above the 4% LFL for hydrogen and the Contractor's 6% limit for oxidants. If, as the Contractor indicated in its presentation to the Defense Nuclear Facilities Safety Board (DNFSB) staff on September 2, 2004, the nitrogen volume will be increased to 10.15 liters and the volume of IX column gas collected reduced to 0.7 liter, the sudden release of an additional one liter of gas at 67% hydrogen would result in a nitrogen-inerted hydrogen concentration of nearly 10% in the collection chamber. Approximately 60 liters of this gas at 10% hydrogen would be released rapidly into the siphon break. Although the hazard is somewhat reduced in this case due to the lower hydrogen concentration in the released gas, the limited mixing that will occur in the siphon break during the few seconds after release might result in flammable compositions. As noted at the beginning of this section, the reviewers identified other potential sources of hydrogen that may add to the volume of hydrogen collected and released to the siphon break. The Contractor must resolve these issues in accordance with COA No. 3 below:

COA No. 3: Develop a plan for (1) evaluating the hazards and (2) identifying controls necessary for ensuring safe operation of the hydrogen mitigation collection system and the siphon break based on the following factors, completing all elements of the plan in time to support the current final Safety Analysis Report (FSAR) schedule:

- Definition of a bounding bubble size considering all sources of releases into the collection system
- Definition of the allowable time and conditions for a column to remain in standby
- Definition of transitory hydrogen and oxygen concentrations in the siphon break as the collected gas and bounding gas bubble are simultaneously released
- Definition of the impacts of differing flush-solution gas solubilities on the composition of the gases in the collection system.

D.3 Reliability of the Hydrogen Mitigation System

The reviewers questioned whether the purge system will have sufficient reliability to satisfy the intent of the top-level principle for reliability found in DOE/RL-96-0006. That principle (section 4.2.7.1) states, "Reliability targets should be assigned to structures, systems, and components or functions important to safety. The targets should be consistent with the roles of the structures, systems, and components or functions in different accident conditions."

The Contractor has responded regarding the reliability of the CXP nitrogen purge system by committing to a formal analysis of the reliability of the system for the Operations Risk Assessment (ORA). In the meantime, the response to question BV-1 argues, the reliability of the system in performing its safety function (preventing flammable hydrogen accumulations) is qualitatively judged to be adequate because,

- The control system will be designed to detect and diagnose failures of the system and automatically activate a continuous vent path on failure.

- If a flammable concentration of hydrogen did occur and ignite, the consequences would be small and mitigated by the secondary confinement system, which includes the cell structure and the C5V system.

The reviewers did not accept the text in the second bullet above as adequate to mitigate against a possible hydrogen deflagration in the bulge which houses the hydrogen collection/inerting piping system. If a deflagration occurred in this system, the cell structure would not provide mitigation since the bulge is located outside and adjacent to the cell. Also, if the piping were breached due to the deflagration, the hydrogen burn combustion gases might be released into the C3 work area. Plant workers in the vicinity may be exposed in this scenario. COA No. 3 includes a requirement that the Contractor evaluate the bounding hydrogen accumulation and hazards (i.e., a deflagration in this piping system) and describe controls to mitigate the hazards.

The reviewers concluded that a primary concern for failure is a single failure of one of several power-operated valves that are actuated frequently during the course of normal operation of the purge system. A review of the various single valve failures that could occur during normal operation supports the Contractor's claim that it is possible, in theory, to design the control system to shutdown the Cs IX pumps and automatically activate a continuous vent path. However, concerns about the reliability of the system's safety function remain because of the potentially high frequency with which the continuous vent path may be in use due to valve failures.

The reviewers also questioned the reliability of the purge system to operate normally. Valve actuations for the purge system are estimated to number in the hundreds of thousands per year based on preliminary operation data submitted by the Contractor. If a valve fails, the Cs IX process must be shut down because there is no backup or redundant purge capability built into the system during normal operation. Even if the control system can place the nitrogen purge in a safe state following a valve failure, the frequency of valve failures rendering the Cs IX process inoperable may be unacceptably high. Based on generic valve failure data published in several nuclear industry databases, the reviewers estimated the IX process could be interrupted on a daily basis due to valve failures in the purge system.

The Contractor responded to issues raised in question BV-1 regarding the reliability of the CXP system to operate normally by questioning whether component demand data *(i.e., the generic nuclear data used in the ORP estimate)* are appropriate for use when the component is demanded frequently as a normal part of system operation. The reviewers acknowledged that the generic nuclear industry data used to estimate the valve demand failure rate is not the preferred source of information for the purge system. Issues regarding the applicability of the generic nuclear data should be resolved by obtaining more component-specific data or analysis. If sufficient design information is available, perhaps product-specific Failure Modes and Effects (FMEA) information may be available from a manufacturer of the components in question. Information from other industry databases like the Offshore Reliability Data (OREDA) database, or the American Institute of Chemical Engineers Process Equipment Reliability Database (AIChE PERD) may have demand failure rates for more frequently operated valves.

In the absence of improved data, the reviewers considered how best to interpret the available generic data for application to the purge system. Two categories of failures are considered in developing failure parameters for failure of a component to change state (e.g., open or closed, running or not running, etc.).

> *Demand failure*: Caused by demand stress during the change in state (opening or closing in the case of a valve). Examples can be vibration, material fatigue, friction wear. Demand failures are modeled with a constant probability per demand.
>
> *Standby failure*: Caused by degradation over time while the system is in a standby mode. Examples are corrosion, moisture in control circuits, and debris in the system. Standby failures are modeled with a constant probability of failure per unit time.

The Contractor stated the generic failure rate (3e-3/demand) consists solely of standby system failures represented by an underlying failure mechanism that is constant in time (constant failure rate per unit time), independent of demand frequency. The Contractor also has stated the failure probability is based on the average probability of failure during a test interval of 1 month. Application of this assumption to failures of the purge system valves implies the demand failure probability for demands more frequent than the underlying monthly test interval must be scaled down by the ratio of (the actual time between demands)/(1 month test interval) in order to preserve the underlying constant failure rate per unit time. The Contractor used this assumption to estimate a failure rate that is 100 times smaller (3e-5/demand vs. 3e-3/demand) than the raw generic data taken from the databases. The Contractor's corresponding estimate for frequency of failure of the purge system to operate normally is then monthly instead of daily.

The interpretation of the generic data by the Contractor implicitly assumes the contribution from "demand stress" failure is *identically zero*. However, the valve failure rate for the purge system comes from contributions due to both "standby failures" and "demand stress" failures. There are several concerns with the assumption of no demand stress failure for the purge system. "Demand stress" failures could be an important contributor to system failure;

- The high demand frequency for purge system valves may result in increased demand stress failure rates due to wear-out of the component (end of life). Individual valves in the purge system may be actuated tens of thousands of times during the course of a year.

- The NRC Handbook for Parameter Estimation in Probabilistic Risk Assessment (PRA) states, "No consensus exists among PRA workers as to which model *(standby or demand failure)* is most advantageous. In particular, the typical mechanisms of failure are not understood well enough to justify a theoretical basis for a model."

- Contrary to responses made by the Contractor to question BV-1, the nuclear industry component failures are not universally predicated on standby failure with a monthly testing interval. For example, studies of emergency diesel generator (EDG) failure rates have found that demand failures (i.e., independent of test interval) can be important contributors to EDG failure. In some cases, EDGs were tested too frequently (worn out by excessive demands from testing). In addition, the Savannah River Site (SRS) database (which was used in the ORP preliminary evaluation of valve failure), included data from systems with a variety of demand frequencies in construction of the generic demand failure rate for valves.

The estimate of the valve failure rate of 3e-5/demand applied by the Contractor is derived from an extrapolation of the standby failure model assumption over two orders of magnitude from the original nuclear industry estimate of 3e-3/demand. Even if the original valve failure data are dominated by standby failures, it is unclear that the same conclusion would apply to such a large extrapolation of this failure model for the high-demand-frequency hydrogen mitigation system. Moreover, the extrapolation has the potentially non-conservative effect of suppressing the "demand stress" failures in the failure rate. Considering the observations in the NRC parameter estimate handbook cited above and the purposes of the preliminary estimate of the purge system failure frequency, the reviewers considered it appropriate to conservatively apply the generic failure data to the purge system using a "demand stress" failure model.

Based on the above discussion, the reliability of the safety function and normal operation of the purge system may not be adequate based on the preliminary application of generic valve failure data. The reviewers were concerned that valve failure data more specific to the high-demand power-operated valves should be obtained and that the overall reliability of the purge system in performing its safety function should be quantified. The Contractor must resolve these issues in accordance with COA No. 4 below.

COA No. 4: By the next PSAR update, quantify the failure probability of power-operated valves in the purge system using component-specific (i.e., not generic) data from the manufacturer or from industry databases. Also, quantify the frequency that the hydrogen mitigation system will fail to perform its safety function of preventing flammable hydrogen gas accumulations due to component failure.

The reviewers also noted that the PSAR ascribes a high reliability to the purge system in Table 3A-9. The table identifies the frequency of IX column explosions as "Beyond Extremely Unlikely (BEU)" because they are prevented by the purge system. The frequency assignment in the table should be deleted because it is not supported by the existing analysis of the purge system (see COA No. 4). The term "Beyond Extremely Unlikely (BEU)" appears to misrepresent the reliability of the system and, therefore, the Contractor must satisfy COA No. 5 below.

COA No. 5: By the next PSAR update, delete the entry in Table 3A-9 of the PSAR that states the frequency of IX column explosions is Beyond Extremely Unlikely (BEU).

D.4 Other Issues

The reviewers noted inconsistencies in the Contractor's assignment of Limiting Conditions of Operation (LCOs) to individual ITS components regarding the provision of uninterruptible power. The Contractor must resolve this issue in accordance with COA No. 6 below:

COA No. 6: By the next PSAR update, correct the PSAR to accurately indicate those ITS components provided with uninterruptible power.

The reviewers identified additional SRD Safety Criteria and standards (Safety Criteria 4.4-3, 4.4-4, 4.5-1, 4.5-2, Appendix B, Section 5.4; Appendix C, Sections 12, 13, 17, 18, 19, 21, and 31) that must be amended to implement the new safety classification scheme for the CXP system. This amendment will be completed if ABAR-24590-WTP-SE-ENS-04-0137, which is under review, is approved by ORP. This issue will be resolved when the following COA No. 7 is satisfied:

COA No. 7: Approval of this ABAR (ABAR-24590-WTP-SE-ENS-03-1144) is contingent on the approval of ABAR-24590-WTP-SE-ENS-04-0137 by ORP.

E.0 CONCLUSIONS

On the basis of the considerations described above, the ORP has concluded the proposed changes comply with applicable laws and regulations and conform to top-level standards. Accordingly, the proposed changes are acceptable and the ORP approves the amendment as proposed in ABAR 24590-WTP-SE-ENS-03-1144, Revision 1, given that the Contractor will meet the foregoing conditions of acceptance.

Attachment 1: Questions and Answers Regarding Safety Systems Identified in ABAR 03-1144

No.	ORP Question/Disposition	BNI Response
JP-1	The preliminary control sketch depicts the main emergency elution isolation valve as V7 (as described in Attachment 6 of the CXP ABAR submittal). The draft P&ID indicates two isolation valves in series. In the event of a fire in the column, these valves would be required to open. Assuming the emergency elution system is classified as Safety Class (SC), single failure criteria would apply. The configuration as depicted lacks redundancy in that a failure of either of these valves in series would prevent emergency elution. This may be acceptable if it can be demonstrated that administrative controls will be in place to permit Operations to initiate the elution process in a timely manner should it be necessary. What is the basis for utilizing two emergency elution valves in series and how will this configuration meet SRD requirements for single failure? <u>ORP disposition:</u> The response is acceptable. The emergency elution system is classified as safety significant (SS) consistent with SRD SC 1.0-6, SC 2.0-1, and PTF Severity Level Calculation 24590-PTF-Z0C-W14T-00002. The two normally closed emergency elution valves in series are acceptable since operators will have sufficient time to manually open them should they fail to open on a column high temperature indication. The column temperature monitoring system is classified SS and provides the operator the means to detect column overheating and to activate the emergency elution function.	The system is not classified as SC. In Consideration of the single failure criterion it was noted that: 1. The time in which to perform emergency elution in the order of days (~110 hours) this assumed loss of liquid in the evaporator and subsequent heat up of the column. PT PSAR 3.4.1.7.1.6 "Conservative calculations in 24590-PTF-Z0C-W14T-00027, however, indicate that approximately 110 hours will be required to evaporate the pore liquid in the hottest part of the resin bed, after the bed has been drained, and to heat the resin bed up to 500 K, a conservatively estimated pyrolysis point." 2. As the valves are located in accessible areas operator intervention was determined satisfactory to account for potential valve failures. Please note: the use of double valve is a standard arrangement to prevent facility worker direct radiation events due to valve failure and subsequent introduction of untreated LAW Feed into an occupied area.
JP-2	Referring to the preliminary control sketch, if gas is detected at L3, the system automatically aligns itself to purge the gas	A column leak will cause L3 to trip and flush the system as described. Operations will detect a problem because

No.	ORP Question/Disposition	BNI Response
	(sequence C as described in Attachment 6 of the CXP ABAR submittal). In this sequence valve V3 is closed to isolate the column. If the reason the liquid level has dropped to L3 is because of a fairly rapid column leak, how is this detected? Note, in the previous design, emergency elution was initiated by either low column liquid level or high column temperature. In the new arrangement, elution is initiated only by high temperature. <u>ORP disposition:</u> The response is acceptable. Loss of liquid level in the column is detected either by the uncovering of level instruments L3/L4 or by an eventual high IX column temperature instrument. Calculation 24590-PTF-Z0C-W14T-00027, Overheating of CIX Media, determined that approximately 110 hours will be required to evaporate the pore liquid in the hottest part of the resin bed, after the bed has been drained, and to heat the resin bed up to 500 K, a conservatively estimated pyrolysis point. Operations personnel will have ample time to take required corrective actions.	the hydrogen mitigation system will be actuating more often then is normal (normal actuation is about once every 30 minutes). As the system is now operated fully flooded this detection system would also detect a leak (uncovering of L3/L4). Significant column leakage would be expected to result in L4 actuation. See response to Q3. Clarification: elution is initiated by high temperature or a loss of flow to a column after a specified time.
JP-3	Under the B Sequence, it is noted that if gas is detected at L4, the IX process pump is stopped and valves 1, 2, and 3 are opened. What happens then? <u>ORP Disposition:</u> The response is acceptable. If gas is detected at L4, the IX pump is stopped and valves 1, 2, and 3 are opened. This is a safe configuration since the gas has redundant paths out of the column. Operations personnel would have sufficient time to assess the cause of gas at the L4 level.	This is considered a safe configuration for the system. At this point the system is under a passive vent. Gas has redundant pathways out of the column. The recovery actions are beyond the scope of the PSAR. However, the cause of the event would need to be understood (e.g., failure of L3, sudden release of gas, etc.).
JP-4	Will the column temperature instruments that initiate emergency elution be redundant? The previous design had only one level	Based on the consequences and time required to heat the column the system is classified as SS. As discussed

No.	ORP Question/Disposition	BNI Response
	switch and one temperature switch which satisfied the single failure requirement for initiating emergency elution. <u>ORP Disposition:</u> The response is acceptable. Emergency elution is initiated by a high column temperature from a SS temperature instrument. Although this instrument is not redundant, single failure was considered as required by SRD Appendix B in that the L3/L4 level instruments will also detect a leak from the column.	above, the L3/L4 will also identify a leak from the column. This coupled with the time required to reach an unsafe condition did not warrant application of the single failure criterion. Note: High temperature in the column automatically initiates emergency elution. However extended loss of flow through the column and frequent actuation of the hydrogen mitigation system are indicators for operator (manual) initiation of the system.
JP-5	Will the valves exposed to nitrogen/hydrogen be of a hermetically sealed design to prevent leakage through the valve stem? <u>ORP Disposition:</u> The response is acceptable. The valves exposed to nitrogen/hydrogen will be specified as bubble tight resulting in very low seat leakage. These valves are typically closed and while in this position no gas will be present in the valve bonnet/stem area. These valves therefore will not require a hermetically sealed valve stem design.	The nitrogen valve "V6" and process purge valve "V1" will be specified to be "bubble tight". Note: If V6 leaks nitrogen will flow into the system as the Nitrogen system is at a higher pressure than the CsIX operating pressure. Leaks through V1 will be indicated by L2 becoming "wetted" which would initiate a flush.
JL-1	For the trap and purge process described for the proposed nitrogen inerting scheme: What is the safety classification and the functional basis for the classification of each valve and instrument (level instruments, temperature instruments, pressure instruments, and flow instruments) and control valves that support the process? <u>ORP Disposition:</u> The response is acceptable. The P&IDs identified safety classifications, and the ABAR provided the basis for the classifications.	All Valves and instruments marked with a "z" on the P&ID 24590-PTF-M6-CRP-00001 are SS, and are not required to meet signal failure criteria. All other components are non ITS. Supporting material for the classification will be provided in the ABAR (draft).
JL-2	The reviewers understand that discrete conductivity probes will be	C&I are using toroidal conductivity sensor for the level

No.	ORP Question/Disposition	BNI Response
	used to detect level. If the conductivity probes became bridged, plugged, or coated by conductive solids or residue, or became otherwise adversely affected by the process conditions, how would this degradation be detected and how would operability of the probe be determined? <u>ORP Disposition:</u> The response is acceptable. The Contractor's response described the principle of operation and configuration of the toroidal conductivity sensor, providing reasonable assurance that the instrument would not be unduly susceptible to these mechanisms, and that flushes would be initiated after every mode change of the IX columns.	detection instrument. The conductivity sensor will be inserted into a valve body. These toroidal conductivity sensors are used in processes where a conventional sensor having electrodes exposed to the measured solution would corrode and become fouled. A toroidal (inductive) conductivity sensor consists of a pair of wire wound metal toroids that are completely isolated from the process. One toroidal coil acts like a transmitter and the other like a receiver. When the transmitter coil is energized, a current is induced into the conductive solution. The receiver coil measures the amount of current, which is directly proportional to the conductivity in the solution. Toroidal conductivity is not sensitive to flow rate or direction of flow. C&I contacted various conductivity sensor vendors and the results were positive for using a toroidal conductivity sensor for our application. A detailed description of the application was given to all vendors. The process fluid that was considered was 0.5 M NaOH. The vender was also made aware the gas could contain flammable gases, including hydrogen and oxygen above the explosive limits. For the toroidal conductivity sensor to successfully measure the conductance of the process fluid, it must be completely submerged. When the sensor is removed from the liquid the conductivity value will decrease to near zero (significantly less than the NaOH solution) regardless if the sensor remains wetted by the process fluid.
JL-2 (cont.)		As for the flammable gas issue, all venders agreed as long as the analyzer is rated Class 1, DIV 1, IS (Intrinsically safe) and is installed to code there is not enough potential

No.	ORP Question/Disposition	BNI Response
		energy to cause a spark at the sensor. Also, flushes will be initiated after every mode changes of the IXCs. For example after fresh resin addition a flush will be initiated to clear all residual particles that are left from the system including the gas collection piping.
JL-3	What design features associated with the conductivity probes will assure their accuracy and appropriate response when subjected to the frequent cycling of successive liquid/vapor/gas states? <u>ORP Disposition:</u> The response is acceptable. As noted in the disposition of ORP Question JL-2, the principle of operation and configuration of the probe provides reasonable assurance that this type of liquid/vapor cycling would not result in adverse performance.	The response for answer two describes the general principle and design features for the toroidal conductivity sensors. The toroidal conductivity cell should not be adversely effected by multiple wetting and drying cycles due to its design. The conductivity sensors/transmitters will constantly provide a 4-20 mA safety signal for the ITS SS Instruments. For the non-ITS instruments a FOUNDATION FIELDBUS (FF) signal will be used if available in an Intrinsically Safe (IS) transmitter. If the FF transmitter is not available a standard 4-20 mA process signal will be used. Based on the transmitter signal the DCS or PPJ system will determine the fluid state (liquid/gas). Vendors have stated that the response time for the instrument to see the liquid/gas separation is nearly instantaneous. Vendors at this time did not provide actual numbers.
JL-4	What safety codes and standards will govern the design and configuration of the conductivity probes and their excitation circuits, wiring, and enclosures? The response should address both ITS and non-ITS probes. <u>ORP Disposition:</u> The response is acceptable. The codes and	The codes and standards applicable to the SS components along with the basis for their selection and tailoring (if required) will be identified in the ABAR. The non-ITS component will be designed in accordance with commercial practices.

No.	ORP Question/Disposition	BNI Response
	standards applicable to SS components were identified in the ABAR consistent with the associated SRD Safety Criteria implementing standards. In addition, in the response to JL-5, the Contractor stated that the instruments would be intrinsically safe and installed to code.	
JL-5	As described in the preliminary documents, it appears that both ITS and non-ITS level instruments would be required to be intrinsically safe to preclude ignition of hydrogen. If safety is an attribute for all of these level instruments, what is the basis for non-ITS classification of the level instruments which are not credited for performing safety related control actions, but which must not present an ignition source? ORP Disposition: The response is acceptable. Both the ITS and non-ITS instruments will be intrinsically safe, rated as Class 1, Division 1, and installed to code. As such, they would not provide an ignition source.	The non-ITS (SS) instrumentation are for process purposes and are not required for properly performing the safety function. These component will however, reduce the demands placed on the SS components. Both the non-ITS control components and the SS control components will be designed to be intrinsically-safe by the instrument vendor and not provide an ignition source. The instrument being intrinsically save does not mean it has a safety function (required to be ITS). Non-ITS instruments can be intrinsically safe. All vendors agreed as long as the analyzer is rated Class 1, DIV 1, IS (Intrinsically safe) and is installed to code there is not enough potential energy to cause a spark at the sensor.
JL-6	What design features will be provided for testing the conductivity probes while in service? How will they be tested in service? ORP Disposition: The response is acceptable. The Contractor stated that it will document the test procedures and test requirements in its Safety System Requirement Specification (SSRS). The Contractor committed to providing ORP with the document for its review when the document is completed.	ITS components will be tested in accordance with testing requirements to maintain the safety integrity level (SIL) of the safety instrumented system (SIS). The test interval has yet to be finalized for this SIS (assumed to be approximately once a year). There is no requirement to test the ITS components while in service. Procedures for testing each SISs will be developed at a later date. Note these features are located in an accessible bulge.

No.	ORP Question/Disposition	BNI Response
JL-7	What design features will be provided for cleaning, maintaining, or replacing the conductivity probes? <u>ORP Disposition:</u> The response is acceptable. The principle of operation of the probe would be expected to reduce the frequency of cleaning requirements, and the sensors will be located in an accessible bulge.	Toroidal conductivity sensors have reduced cleaning requirements when compared to conventional sensors because of their use of inductive measurement principles. All components are built into an accessible bulge. The conductivity sensor will be inserted into valve bodies. For an example see an Emerson product (Rosemount analytical) Valve Insertion Assemblies For the Model 228 Sensor. The conductivity transmitter will be located on a rack in a C3/R2 area.
JL-8	The proposed trap and purge process is a batch process that would replace the continuous level control/protection process currently described in the PSAR. What methodology and analytical tools will be used to assure that the proposed control scheme will satisfy single failure criteria and functional requirements with respect to performance of the required safety functions? <u>ORP Disposition:</u> The response is acceptable. The Contractor stated that its safety system requirements specification (SSRS) will present or reference the failure modes and effects analysis for the trap and purge control scheme. The SSRS will be provided to ORP for its review when it is completed.	The classification of the CXP hydrogen mitigation system is SS. For the individual active elements/sub-systems of the hydrogen mitigation system have been qualitatively evaluated for failure modes and impacts to determine the risk posed by their failure. This analysis will be included in ABAR (draft). In consideration of the need to address single failure, it should be noted that even under postulated failure conditions (explosions) the C5 boundary is not expected to be compromised, thus, any release will be mitigated to below unacceptable consequences.
JL-9	How will the independence of the non-ITS level instrument channels from the ITS level instrument channels be assured, such that failures of non-ITS level instrument channels will not cause or result in a condition which could adversely challenge the ITS level instrument channels? As a specific example, sequence A requires gas detection at L1 and L2 to work properly to initiate a flush,	L2 is connected to the non-ITS normal DCS system for normal control of the flushing system. L1 is connected to the ITS PPJ system to initiate a purge and system shutdown if the DCS controls fail. The design of the PPJ (ITS) and DCS (non ITS) follows

No.	ORP Question/Disposition	BNI Response
	which is a safety function. The response should address hardware and software design features, and the degree of redundancy and diversity provided. <u>ORP Disposition:</u> The response is acceptable. The description provided in the response is consistent with applicable SRD safety criteria.	the philosophy of defense-in-depth in accordance with the ISM process as the PPJ and DCS are independent of each other. The normal control of a system is designed to keep the process parameters and operations within safe design limits. These normal controls are accomplished through the DCS system. This particular hydrogen control system, under maximum demand, could be operating the proposed flushing system every few minutes. In accordance with the ISM process, certain scenarios need supplemental controls, independent trips and interlocks. In this case it is assumed that supplemental controls will be required to mitigate the hydrogen hazard from the Cesium ion exchange columns. The ISM process designated these additional controls, trips or interlocks as Safety Significant. The SS controls are implemented in the safety instrument system, PPJ. These additional controls shall have sensors dedicated to the PPJ. The PPJ system provides a "safety umbrella" for the plant and is normally only relied upon after the normal control system has failed to control the process.
JL-10	What design features will be provided to timely detect inadvertent isolation of the level instruments as a result of incorrect valve lineups? <u>ORP Disposition:</u> The response is acceptable. Valve lineups will be supervised by the DCS by monitoring position limit switches to provide reasonable assurance that an instrument is not inadvertently isolated.	The DCS system will be the governing system that detects valve lineups. All valves will be provided with open/close limit switches.

No.	ORP Question/Disposition	BNI Response
JL-11	Safety Criterion 4.3-4 stipulates, in part, that: " ITS instrumentation and controls shall be provided to monitor variables and systems and control systems and components over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate public and worker safety….The instrumentation and controls provided shall provide the ability to detect off normal conditions, mitigate accidents, and place the facility in a safe state…" For the proposed trap and purge process, what instrumentation will be used to satisfy SRD Safety Criterion 4.3-4 and its tailored implementing standard IEEE Std 497-2002, *Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations*? What variable types (A, B, ~~C~~, D, ~~or E,~~ as defined in the tailored IEEE Std 497) are assigned to the instrumentation? Provide the basis for the variable type assigned. <u>ORP Disposition:</u> The response is acceptable. ORP will verify the Contractor's implementation of the tailored version of IEEE 497 during its inspection.	The process to classify variable types per IEEE 497 is being implemented as a separate activity to ensure consistent Project wide application as identified in 24590-WTP-ENS-SE-03-478.
JL-12	Why is the distinction between "gas" and "liquid" detection? Is an intermediate gas/liquid state detection a possibility? Please elaborate. <u>ORP Disposition:</u> The response is acceptable, based on the principle of operation of the conductivity probe.	For the toroidal conductivity sensor to successfully measure the conductance of the process fluid, it must be completely submerged. When the sensor is removed from the liquid the conductivity value will decrease to near zero (significantly less than the NaOH solution) regardless if the sensor remains wetted by the process fluid (gas detection). If foaming happens the conductivity will be much less than the caustic based fluid. The conductivity

No.	ORP Question/Disposition	BNI Response
		will be a step change function. A high conductivity value will be present while the sensor sees the conductive process fluid. A low conductivity value will be present when the sensor sees the no conductive gas regardless if the sensor remains wetted by the process fluid. No intermediate detection state is required.
JL-13	In sequence A, why is detection of gas at both L1 and L2 required rather than just relying on L2 alone? L1 seems to have been assigned both safety and control functions. <u>ORP Disposition:</u> The response is acceptable. The revised version of the ABAR corrected the description of the sequence, as described in the response.	Note: This is a problem with the wording of the sequence operation. This will be corrected in the ABAR (draft) Level switch L1 is a safety switch and is not used by the process control system. If L1 detects liquid longer than the allowed time, then it will trip (independently of the process control system). If L2 detects liquid after the specified gas volume has been placed in the system (from flow totalizer F), then this will initiate a process flush operation to reestablish the nitrogen blanket. Note: L2 will be located such that it should not detect liquid when the proper volume of nitrogen has been added.
JL-14	If the Cs IX hydrogen mitigation system and its instrumentation, control and support power is required to perform its function during and after a design basis seismic event, why was IEEE Std 344 excluded from the applicable standards identified in proposed revisions to PT PSAR 4.4.16.4? <u>ORP Disposition:</u> The response is acceptable on the foregoing basis.	IEEE 344 is applicable to SDC/SDS or SC/SS Seismic Class I electrical and instrument system design. This standard was excluded because the Cs IX system is classified as SC-III and has valves that can be manually actuated to assure its function.

No.	ORP Question/Disposition	BNI Response
JL-15	SRD Safety Criterion SC-4.3-5 requires in part that: *When single failure protection is required, Important to Safety protection systems shall be separated from control systems to the extent that failure of any single control system component or channel, or failure or removal from service of any single protection system component or channel which is common to the control and protection systems leaves intact a system satisfying all reliability, redundancy, and independence requirements of the protection system.* Even if the ITS portion is not redundant, if the level control system includes both ITS and non-ITS components and circuits, it appears this Safety Criterion should apply, because of the potential for interaction from the non-ITS components, Why was SC-4.3-5 excluded from the functional requirements and other safety criteria identified in the proposed revisions to PT PSAR 4.4.16.3? ORP Disposition: The response is acceptable on the foregoing basis.	As noted in attachment #3 of 24590-WTP-SE-ENS-03-1144, Rev. 1 the overall system provides adequate protections as any one of the controls could be removed and the event still would be prevented. Single Failure criterion is not necessary for the Level Detection System because the PPJ and PCJ are not required.
JL-16	ABAR 03-1144, Attachment 5, CCN 086719, CXP Standards Discussion, p. 2 (IEEE 344 discussion): The discussion of SC 4.1-3 appears to propose the use of “experience” in lieu of seismic qualification testing in accordance with IEEE Std 344-1987. Why and how could this be acceptable for SDC or SS C&I or electrical equipment? ORP Disposition: The response is acceptable on the foregoing basis.	IEEE 344 is applicable to SDC/SDS or SC/SS Seismic Class I electrical and instrument system design. The Cs IX system is classified ad SC-III, while the discussion of experience is consistent with DOE 1020 (which does not require testing).

No.	Comment/Disposition	Response
RT - 1	Drawings provided by BNI (24590-PTF-M6-CXP-00014, Rev 0 and 24590-PTF-M6-CRP-00003, Rev 1) show the flow path for backflow of feed through the nitrogen flow control system is unrestricted until a check valve is encountered between the flow control system and the nitrogen bottles. The flow control system is apparently not contained within a bulge or other containment device. What are the consequences of a rupture in the lead column's nitrogen flow control system/piping, or erroneously opening valve CXP-V-13323, -13325, -13327, or -13329? What control(s) will mitigate the consequences? ORP Disposition: The response is acceptable. As noted, a significant leak would result in lowering the line pressure and automatically shutting off the feed pump, thereby stopping the leak. A slow leak would eventually result in liquid being detected at L2 and/or L1, also resulting in automatic shutdown of the pump. The expected small amount of leakage in either scenario would have moderate FW consequences because the liquid in the hydrogen mitigation system would consist largely of flush solution rather than highly radioactive IX column feed.	A break in the line or an erroneous valve opening (V-13323/13325/13327/13329) would result in the four pressure indicators (PI-1405/1407/1414/1416, two on each train of the nitrogen supply system) shutting down the pumps to the IX columns. To release fluids would require the line break concurrent with the system trying to re-establish a nitrogen blanket or a second failure of a valve, then the volume of the caustic solution in front of the LAW would need to be expelled first. With the pumps off, the level of fluid in the system will balance to the level of the highest breakpot which limit the driving force for expelling fluid. The elapsed time between detection of low nitrogen pressure by the pressure indicators (less than 80 psi) and turning off the pressure to the IX pumps is most likely significantly less than the time it takes for the column to expel LAW solution. In the unlikely event that LAW solution does make it out of the column, the resulting severity levels are estimated to be Moderate to the FW, SL-3 to the CLW, and SL-4 to the public, based on a nominal discharge of LAW solution.
RT - 2	Sampling capability is provided for each stream exiting the four ion exchange columns in the ASX-SMPLR-00015 Auto Sampler Cabinet (24590-PTF-M6-ASX-00001, Rev 1). Each sampler is connected to the deionized water and service air systems. Three non-ITS check valves in series and a remotely actuated non-ITS	For this situation to occur, the return lines at each sampler must be plugged, and then the three non-ITS check valves and a remotely non-ITS ball-type valve would have to fail. If these things happened, then the normal operating pressures of the Plant Service Air (100 psig) and

No.	Comment/Disposition	Response
	valve (ball-type?) provide protection against backflow of treated LAW via the samplers into these systems. No other backflow controls are apparent on the drawings. What are the potential for and consequences of backflow of waste solution from the IX columns? ORP Disposition: The response is acceptable. Although the pressurized waste sampling system is piped directly to the deionized water and service air systems, the simultaneous failure of the three check valves, loss of overcompensating pressure in the deionized water or the service air systems, and lack of appropriate operator intervention make backflow of contamination into the deionized water and service air systems beyond extremely unlikely.	Demineralized Water (80 psig) is greater than or equal to the maximum operating pressure of the column at that elevation (80 psig). The operating pressures would prevent such a backflow event from happening.
RT - 3	ASX-SMPLR-00015 Auto Sampler Cabinet (24590-PTF-M6-ASX-00001, Rev 1) drains through a 2" pipeline to the PWD system. Several 2" pipelines and one 3" pipeline contain solutions under pressure inside the cabinet. It is unclear how the 2" drain will prevent leaks from a ruptured pipe or disassembled sampler from overfilling the cabinet and leaking out the cabinet's HEPA filters to the floor. The drawing shows no liquid detector or other device to warn of a leak. Have calculations been performed that show the drain capacity of the 2" pipeline is adequate in the case of an open 3" pipeline under normal process pressure? If not, what are the consequences of overfilling the cabinet, and are additional controls being considered? ORP Disposition: The response is acceptable, based in part on ORP's recent closure of condition of acceptance (COA) 4 of ORP/OSR-2003-22, Rev 0, which addresses proper sizing of bulge	The ASX-SMPLR-00015 cabinet drainpipe size is on hold and will be sized for a single line, maximum flow-rate line failure as determined by "Pretreatment Bulge Drain, Vent, and Inbleed Line Sizing & recommended HEPA Filter Pressure drop", 24590-PTF-M6C-10-00001, Rev 00A. Additional protection is provided to the cabinet by a liquid level detector directly above the drain. The level detector is connected to LAH 1232 and LSH 1232.

No.	Comment/Disposition	Response
	drains, in general. The Contractor's recent supporting report, "Evaluation of Drain Paths from PTF Bulges", CCN: 085328, shows that the bulge vent is capable of providing the drainage function, irrespective of drain size. Proper sizing of the drain and vent line, and use of the liquid level detector will mitigate the hazard.	
RT - 4	Chilled water in the Cs IX feed heat exchangers (CXP-HX-00001A/B on 24590-PTF-M6-CXP-00001, Rev. 1) will be subject to high radiation fields, resulting in hydrogen generation. The hydrogen will be disengaged from the chilled water in CHW-VSL-00024. The vapor space in this vessel apparently is not actively purged. What is the expected level of hydrogen in the tank's headspace, considering all sources of radiolytic hydrogen for the deionized water system under normal operations and maximum radionuclide concentrations? Hydrogen also will be generated when the chilled water system is not being operated, and it will accumulate in high points in the piping. Considering the maximum accumulation possible, what is the projected hydrogen concentration in the vessel headspace soon after pumping the chilled water is resumed? <u>ORP Disposition:</u> The response is conditionally acceptable per subsequent informal ORP and BNI agreement to address hydrogen hazards in this system as part of resolving the existing Condition of Acceptance (COA) (Item 5[c], Section No. 4.2, of *Safety Evaluation for WTP Construction Authorization, ORP/OSR-2003-01*). See Section Dof this SER for specific COAs assigned to this ABAR.	Air separator vessel CHW-VSL-00024 is a flooded vessel that releases air with a valve to a C3 area, which is then cascaded back to the C5 ventilation.
RT - 5	In the event of loss of power, it appears all valves upstream and	The current design intent is to minimize the amount of

No.	Comment/Disposition	Response
	downstream of the Cs IX feed pumps (CXP-PMP-0001A/B on 24590-PTF-M6-CXP-00001, Rev. 1) fail closed, thereby fully isolating feed solution within these piping segments. Similarly, the piping segments between the downstream pump isolation valves and the Cs IX feed header to each column also appear to be filled with feed and fully isolated upon loss of power. At maximum radionuclide concentrations, what pressure will be developed in these segments due to radiolysis of the solutions? ORP Disposition: The response is conditionally acceptable pending the Contractor's submittal and ORP acceptance of the Contractor's report on the investigation of piping that can trap hydrogen. See Section Dof this SER for specific COAs assigned to this ABAR.	piping that will collect hydrogen gas. When design drawings that provide a true representation of piping are issued (not the alpha preliminary drawings as examined), a thorough investigation of piping that can trap hydrogen will be initiated.
RT - 6	Upon loss of power, hydrogen and other radiolytic gases will build up and eventually fill the vertical pipe segment between the Cs IX column's inlet flow distributor (24590-PTF-M6-CXP-00002/3, Rev. 1) and the column feed header valve (e.g., YV 0202), which fails closed. Note that the hydrogen that will build up in this segment is additive to the hydrogen in the two segments addressed in Question RT-5 when operations resume. At maximum radionuclide concentrations, how much hydrogen from the three segments will be released suddenly to the lead Cs IX column when operations resume? What are the consequences of this release? How will the Hydrogen Mitigation System on the lead column accommodate the release of this hydrogen? ORP Disposition: The response is conditionally acceptable pending the Contractor's submittal and ORP acceptance of the Contractor's report on the investigation of piping that can trap	The issue of hydrogen collection within piping is an ongoing activity whose completion requires the issuance of design drawings that provide a true representation of piping (See response to question #5).

No.	Comment/Disposition	Response
	hydrogen. See Section Dof this SER for specific COAs assigned to this ABAR.	
RT - 7	The treated solution from the lead IX column will pass from the base of the column upward through a pipe located close to the column and flow to the lag column. Under design-basis loading conditions in the lead column, what is the dose rate to the treated solution in this pipe? At what rate will hydrogen be generated in this pipe under these conditions? What are the consequences of discharging the accumulated hydrogen to the lag column when operations resume? How will the Hydrogen Mitigation System on the lag column accommodate the release of this hydrogen? <u>ORP Disposition:</u> The reviewers disagreed with the response, which appears to be based on a misunderstanding of the question. A revised question was subsequently submitted as RT-21. The response to RT-21 was conditionally accepted per a subsequent informal ORP and BNI agreement to address hydrogen hazards in this area as part of resolving existing Condition of Acceptance (COA) (Item 5[c], Section No. 4.2, of *Safety Evaluation for WTP Construction Authorization, ORP/OSR-2003-01*).	The amount of hydrogen generated under these conditions is bound by the column generation rate for LAW and would be a function of time and ability of the piping to retain gases. However, the consequence of discharging the gas is expected to be much less than the one-liter bubble assumed for sizing the siphon-break. Thus, if a bubble of hydrogen is large enough, LS-4 will be tripped, the bubble will travel to the siphon-break and be diluted to less than the LFL. If the volume is small enough not to trigger the lower level switches, the nitrogen blanket system will handle the event.
RT - 8	A sampler in ASX-SMPLR-00015 Auto Sampler Cabinet (24590-PTF-M6-ASX-00001, Rev 1) is located at the apex of the pipeline that may contain hydrogen and other radiolytic gases. What are the consequences of hydrogen accumulation to a worker who performs maintenance on the samplers? How will the risk be mitigated? <u>ORP Disposition:</u> The response is acceptable. Adequate flushing of the line can remove a bubble that otherwise could burn or	Workers who perform maintenance on the samplers will have to receive a work permit to do so. Prior to this work, the column/pipe will be flushed with caustic, thus eliminating any potential hydrogen accumulation in the pipe work.

No.	Comment/Disposition	Response
	explode when workers open up the piping to conduct maintenance.	
RT - 9	As shown on (24590-PTF-M6-CXP-00002/3, Rev. 1), each column is equipped with a rupture disk designed to rupture at 125 psi. The rupture disk appears to be connected to a nozzle at the top of the column, thereby creating a vertical pipe section in which additional hydrogen will accumulate. How much gas will accumulate in this section and what are the consequences? <u>ORP Disposition:</u> The response is conditionally acceptable pending the Contractor's submittal and ORP acceptance of the Contractor's report on the investigation of piping that can trap hydrogen. See Section Dof this SER for specific COAs assigned to this ABAR.	On issued drawings 24590-PTF-M6-CXP-00002/3, Rev. 1 these rupture disks are on hold. The design intent is to have these rupture disks on the side of the columns as to minimize the amount of hydrogen collection. When design drawings that provide a true representation of the column design are available, a thorough investigation of areas that may trap hydrogen will be initiated (See questions #5 & 6).
RT - 10	The Hydrogen Mitigation System located atop each IX column is intended to prevent unsafe accumulations of hydrogen in dead zones. However, a review of the untitled plan and elevation views of the bulge that contains the valving associated with this system indicates that there are apparently several locations where hydrogen will accumulate, albeit in lesser quantities than observed in the previous questions above. Examples include a dead leg below valve CRP-YV-0145 (about 2' of 3" pipe) and a dead leg below valve CRP-YV-0321 (about 2' of 1" pipe). What are the consequences of these accumulations? <u>ORP Disposition:</u> The contractor provided an acceptable response to this question in follow-on question RT-30. Also, see Section Dof this SER for related COAs assigned to this ABAR.	The issue of hydrogen collection within piping is an ongoing activity whose completion requires the issuance of design drawings that provide a true representation of piping (See response to question #5, 6, and 9).
RT -	Radiolytic gases will nucleate and grow on the surfaces of the	Under normal conditions, liquid is always flowing through

No.	Comment/Disposition	Response
11	resin particles in the column when no solution is passing through the resins. The resin particles are small enough that the gas bubbles can be confined within the interstices of the resin bed until the resin/bubble density is sufficiently buoyant to suddenly release the collected gas. At maximum radionuclide concentrations, how much hydrogen can be released in this event? If significant, how does this quantity factor into the design of the Hydrogen Mitigation System when pumping through the column is curtailed at the time L3 indicates the presence of gas? <u>ORP Disposition:</u> The response is partially acceptable. The unanswered parts were rephrased under RT-22.	an ion exchange column until it has been eluted and regenerated. Once regenerated, the column will likely be in standby with no flow; however, with essentially all the cesium removed, there will be little gas generation. In the event of no flow through an operating column, the hydrogen control system is designed to react to a release of a large bubble (i.e. LS-4). Under extended no flow conditions, operator monitoring and column temperature would indicate a need to perform elution. When L3 indicates the presence of gas the normal sequence would be to purge the system.

No.	Comment/Disposition	Response
RT-12	In regard to the “Preliminary Control Scheme – Nitrogen Blanket in CXP System, Rev. 1” and associated “Figure One (Hydrogen Mitigation System)” • For “Emergency Elution”, Step 2, should the vessel be CNP-VSL-00003 rather than CRP-VSL-00003? <u>ORP Disposition:</u> Correction accepted. • Immediately following “Emergency Elution”, Step 3c, should the pressure at “P” be verified as below the head of the three tanks of the emergency elution system before starting addition of emergency elution solutions? If the system is still pressurized because of blockage of V1, contamination will be blown up into the emergency elution system as the pressurized gas in the Hydrogen Mitigation System expands. <u>ORP Disposition:</u> The response is acceptable. Stopping the process pump as stated will reduce the pressure to that of the static head of the liquid as stated in the response, thereby preventing the release of pressurized liquids and gases into the elution chemical vessels.	• Yes • Measuring pressure is not necessary. Step 1 stops the ion exchange process pumps, which are the sole source of dynamic pressure in the system. Therefore, only static pressure will exist in the ion exchange columns.

No.	Comment/Disposition	Response
RT-12 (cont.)	• For “Emergency Elution”, Steps 4 through 9, should the order of addition of the solutions be reversed? Adding caustic first as shown would have little effect, and adding nitric acid last would elute the column but leave it in a reactive state. <u>ORP Disposition:</u> The response is acceptable. In its response to RT-23, the Contractor stated that “emergency elution of a column will be followed with a caustic regeneration step to remove acid from the resin bed.” This alleviates the concern that the Contractor was planning to perform a truncated emergency elution that may be ineffective or leave the resin in a potentially unsafe condition. • For “Establish Nitrogen Blanket”, Step A5 should be “Close valve 6” as confirmed by BNI staff. <u>ORP Disposition:</u> The response is acceptable. This question was restated as RT-24, with the response that step A5 should be “Close valve 6”.	• No, the sequence is correct. First, sodium hydroxide is added to displace the LAW feed. If water or nitric acid were used first, the change in pH would likely result in precipitation and plugging the resin bed. Second, water is used to displace the sodium hydroxide to preclude an acid-base reaction. Finally, nitric acid is used to remove the cesium. • Do not understand the statement. As part of the automated control sequence, valve 6 will close after the correct amount of nitrogen is added. There is no requirement for a person to verify the valve’s state.

No.	Comment/Disposition	Response
RT-12 (cont.)	• Immediately following "Purge Gas Collection Piping", Step 2, should the pressure at "P" be verified as below the head of the caustic tank before starting addition of caustic solution? ORP Disposition: The response is acceptable. The contractor committed to evaluate the issue during the HazOp process.	• The pressure can be checked before opening valve 5 to the caustic supply. This will be evaluated during the HazOp process.
	• If the system is still pressurized because of blockage of V1, contamination will be blown up into the caustic tank as the pressurized gas in the Hydrogen Mitigation System expands. For "Purge Gas Collection Piping", Step 2, leaving valves set for XX seconds provides no direct indication the large volume between L1 and V1 has been purged with caustic. That volume appears to be perhaps an order of magnitude larger than between L3 and L1. The safety of the Hydrogen Mitigation System relies on fully purging the system between cycles. Two causes of incomplete purging include (1) a partially plugged caustic pipe and (2) a failure of V1 to open past the first stop. Explain why another level sensor is not needed in proximity to V1. ORP Disposition: The response is acceptable. The Contractor pointed out that blockage of V1 can be deduced using L3 and L4 (and knowledge of the volume of nitrogen added), and then the system would be placed in a safe passive state.	• If the purge step failed to remove the gas from the piping, then L3 will be tripped during nitrogen addition (step C7) and the purge will be reinitiated. Indication of a problem will be evident due to re-purging or more rapid purging than expected. If this situation continues, then gas will collect to L4. When L4 is not wet, the IX system will be stopped and both the primary and secondary purge routes opened (via valves 1 and 2) to the siphon-break. This places the system in a safe, passive state. No additional sensor is required.

No.	Comment/Disposition	Response
RT-13	Previous Russ Treat questions addressed the potential for accumulating bubbles containing at least one liter of hydrogen in several locations in the CXP and related systems. Locations where hydrogen may accumulate are high points in pipelines that are not connected to the Hydrogen Mitigation System and those that will be purged on an irregular frequency to the Hydrogen Mitigation System. Such locations include the sampling stations between IX columns, dead legs near specific Hydrogen Mitigation System valves, and high points in the chilled water system used to cool the feed to the IX columns. Previous responses refer to a one-liter bubble of hydrogen and the ability of the Hydrogen Mitigation System to mitigate the hazards of bubbles of this size by dilution with nitrogen. As noted in Section 3.4.1.8.4 of the SED, "Accumulated hydrogen in the column can be postulated to be ignited by static discharge, electrical discharge from instruments, or arcing from lightning strike grounding through a path that includes the IX column." Although it is understood that BNI is investigating design options that may eliminate most points of hydrogen accumulation, it appears that discrete hydrogen-containing bubbles of some size will be present at certain points and at certain times in the CXP and related systems. These bubbles may ignite before the hydrogen is diluted with nitrogen or air.	BNI does not expect bubbles in solution to be ignitable due to the short time such bubbles would exist and the lack of a credible ignition source, the risk of exploding bubbles can be considered vanishingly small.

No.	Comment/Disposition	Response
RT-13 (cont.)	Is there a size of bubble below which ignition of the bubble is beyond extremely unlikely? If so, what is the bubble size and basis for its lack of ignitability? What pressure would be generated in the vicinity of a one-liter or other size bubble that contains hydrogen (generated through radiolysis and/or thermolysis) and oxidizers (e.g., oxygen and NOX also generated through radiolysis and/or thermolysis) at the optimum ratio for ignition and complete reaction? What is the expected frequency of such ignitions? Are associated jumper connectors, instruments, valves, and vessels being specified to accommodate the resulting shock wave/pressure? What are the projected impacts of ignition of bubbles containing more than one liter of hydrogen if the accumulation of such bubbles is credible? <u>ORP Disposition:</u> Although the response does not address the questions, ORP and BNI agreed to address the hydrogen hazards in this system (other than the dead legs in the hydrogen mitigation system) as part of resolving existing Condition of Acceptance (COA) (Item 5[c], Section No. 4.2, of *Safety Evaluation for WTP Construction Authorization, ORP/OSR-2003-01*). Hence, the response is conditionally acceptable. See Section Dof this SER for specific COAs assigned to this ABAR.	
RT-14	Unlabeled BNI plan and elevation drawings of the Hydrogen Mitigation System indicate that a substantial volume of space (probably greater than 10 liters) exists between the level indicator (L1) furthest removed from the column and the air-purged siphon break. If this space is kept filled with liquid, hydrogen cannot build up in the space, thereby precluding ignition. If the liquid level in this space is allowed to drop undetected to some level above L1 during a period of operational standby when V1 and V3	BNI agrees that if the liquid level dropped to this point (some level above L1 with V1, V3, and possibly V2 open) that hydrogen could gradually accumulate. However, since siphon break (CRP-ZF-00003-S11B-16) is the lowest of the siphon breaks associated with the CXP system, the caustic solution used to flush the lines to the other siphon breaks will back-flow and fill the line; thus, preventing accumulation of hydrogen in an area without

No.	Comment/Disposition	Response
	(and possibly V2) are open, hydrogen could gradually accumulate. Accumulation is possible because there is no apparent means to sweep this space with flowing air as in the siphon break, and because diffusive dilution with air does not appear feasible at the column's relatively high design-basis hydrogen generation rate. What control will be used to prevent the buildup of ignitable quantities of hydrogen in this space when undetected slow leakage of liquid from the column causes the liquid level to drop and create space for collecting hydrogen (especially during a period of passive venting when in an operational standby mode, but before required elution)? ORP Disposition: The Contractor recognized that additional strategies, such as flushing, will be required to keep this line segment from accumulating hydrogen during any long shut-down. The response is conditionally acceptable pending the Contractor's submittal and ORP acceptance of the Contractor's report on the investigation of piping that can trap hydrogen. See Section Dof this SER for specific COAs assigned to this ABAR.	the ability to be purged. BNI recognizes that a limited amount of caustic solution can back-flow to this siphon break and that additional strategies will be required, such as a flush of this line with caustic, or performing elution for any period of long shut-down.
RT-15	Gas leakage from the Hydrogen Mitigation System may compromise the reliability of the "gas detected at L3" basis for automatically flushing the Hydrogen Mitigation System. The response to Question JP-5 indicates that V1 and V6 will be bubble-tight. Bubble-tightness of the flange seals for L1 and L2 may be more difficult to guarantee since the area of the seal will be substantially larger than the valve stem seal. An overall rate of gas leakage from these locations that roughly equals the rate of hydrogen generation will result in the gradual buildup of hydrogen within the Hydrogen Mitigation System unless the L3 control is overridden by a time-based or other control such as a hydrogen	In the advent of a leak from a flange seal exactly matching the hydrogen generation rate within the column, the hydrogen mitigation system will be flushed every mode. If the leak rate does not exactly match the columns hydrogen generation rate, the system will automatically flush and reestablish a nitrogen blanket, or go into bypass mode. Additionally, the valves and instrument bodies associated with the hydrogen mitigation system have been specified as bubble-tight. This requirement will be verified during with the verification process during commissioning, start-up, and general maintenance modes.

No.	Comment/Disposition	Response
	sensor for initiating caustic flushing. A time-based control would somehow have to account for the increasing rate of hydrogen generation as the column becomes loaded with Cs-137. How will the potential for gas-leakage from the V1, V6, L1, and L2 seals be accommodated to prevent the formation of unsafe levels of hydrogen in the Hydrogen Mitigation System? <u>ORP Disposition:</u> In discussions with the Contractor, the Contractor recognized that the rate of hydrogen generation will not be static; it will increase with loading on the bed. Thus, it is reasonable to assume there could be a cross-over point at which the rate of radiolytic gas generation exactly matches the static rate of gas leakage. This condition, which could eventually cause all of the hydrogen diluent to be purged from the piping, could be mitigated by using a default time (e.g., 1.5X the previous cycle time for one cycle) for initiating a purge of the hydrogen mitigation system. The Contractor agreed to implement a control to either verify that gas leakage is not occurring or to otherwise ensure that the nitrogen diluent is not displaced over time. The response is conditionally acceptable pending the Contractor's submittal and ORP acceptance of the Contractor's control. See Section Dof this SER for specific COAs assigned to this ABAR.	
RT-16	The Safety Evaluation for Design (24590-WTP-SE-ENS-03-1144, Rev 1) and the Safety Envelope Document (24590-WTP-SE-ENS-03-1144, Rev 0, Attachment 1d) describe a new DBE involving IX column blowdown caused by malfunction of either the nitrogen addition system or the siphon air purge system. Prevention of both these malfunctions, which could leave the IX resin exposed to air, is discussed in these documents. It appears that a third malfunction might cause the same DBE, i.e., service air injection	The exact same controls used for dealing with a blow down of purge air or nitrogen is applicable to a service air injection blow down. This event will result in the system purging the gas collection piping. When the system is passively vented, it will take the path of least resistance to the siphon break, resulting in a loss of motive force and the ability to blow-down the column. If the system does not go into the passively vented mode, the temperature

No.	Comment/Disposition	Response
	into the pipelines between the IX columns via any of the four sample stations (the low level of detail on the drawing creates uncertainty, however). If air can be injected via this pathway, what controls will prevent or mitigate the DBE? <u>ORP Disposition:</u> The response is acceptable. The Contractor indicated that the controls established for the nitrogen blowdown case will be effective in this case as well.	indication and emergency elution system would initiate and place the column in a safe condition.
RT-17	The Safety Evaluation for Design (24590-WTP-SE-ENS-03-1144, Rev 1) and the Safety Envelope Document (24590-WTP-SE-ENS-03-1144, Rev 0, Attachment 1d) indicate that C5 Ventilation is now included as defense in depth and that it will withstand soot plugging in the event of resin fires and explosions. Since the resin may be loaded to 150,000 curies of Cs-137 at the time of a fire, the potential dose rates at the C5 HEPA filters may be extremely high. Are these dose rates bounded by the current design basis dose rates for the filter room? How will the C5 HEPAs withstand the soot loading and air-entrained sparks in the case of a fire, ensuring the co-located worker and the public remain protected? <u>ORP Disposition:</u> The response is acceptable for the case in which the resin is contained within the column. In this case, the emergency elution system precludes the possibility of a fire or at least provides the ability to quickly suppress it. Discussions with the Contractor for the case in which the resin spills from the column resulted in follow-on question RT-25.	The fire event is prevented by the controls documented within attachment 1d for the following DBEs: • Resin Dry out and Overheat Due to IX Column Leak • Continued for Boiling/Evaporation of IX Column Liquids Due to Long-Term Loss of Flow • Continued for Resin Dry-out Due to a Nitrogen (Blow down) • Ion Exchange Hydrogen Mitigation. With the controls selected for these scenarios, there is no fire or explosion. However, a fire is a long time in developing (~110hrs) and by the time the fire could occur the emergency elution system would have eluted the column. Thus, there is no additional loading on the HEPA filters due to a fire. With respect to the protection of the co-located worker or the public from the event, again the event is prevented. We have no way of characterizing the soot loading because the resin properties are proprietary. A fire with the potential to plug the HEPAs is identified as a BDBE in the DBE calculation.

No.	Comment/Disposition	Response
RT-18	The response to RT – 1 indicates that LAW solution from a column discharged into an apparent C3 area through valve CXP-V-13323, -13325, -13327, or -13329, or through a ruptured pipe would result in a moderate severity level exposure to the FW, SL-3 to the CLW, and SL-4 to the public. Ion exchanger feed pumped to the lead column in this event would pass directly through the Hydrogen Mitigation System piping and out into the C3 area before any Cs-137 has been removed. Please define the material at risk for this lead column discharge case, and all supporting assumptions that lead to a moderate facility worker severity level. Please consider the possibility that an accident coincidently disables the nitrogen pressure element and ruptures the connecting nitrogen supply pipe, thereby eliminating the interlock signal to shut down the IX column feed pump and stop the discharge. <u>ORP Disposition:</u> The response is acceptable. The Contractor described the interlocks that will prevent a significant spill of untreated LAW into the C3 area where the nitrogen bottles are located.	The assumptions that lead to a moderate facility worker severity level are as follows: 1. Untreated law is more dense than the caustic, thus the untreated LAW will sit in the column and not the piping. 2. With assumption #1, we have 10 liters of nitrogen, followed by 1.5 liters of caustic held above V3 (trap piping). 3. That we have roughly 75 feet of 3" pipe from the top of the column up to V3, and again with assumption #1, we have roughly 30 gallons of caustic contained within this pipe. With these assumptions, and the fact that the dose rate 1' from the center of a spill of CXP01 (a spill that is 4' in diameter) is 5.273 mR/hr, a facility worker would have to ignore the significant volume of caustic fluid prior to seeing untreated LAW. If we consider the possibility of the same scenario combined with disabling PT 1407 and or 1416, it would not matter. As soon as the PPJ system did not see the signal from either one of these transmitters, the following valves will be closed 0352, 0345, 0338, 0331, 0117, and 0127. Closing these valves isolates the columns from the pumps and the hydrogen mitigation bulge from the nitrogen supply system. In addition to these valve closures, the bypass route through the hydrogen mitigation system will be opened; thus effectively mitigating the concerns of this accident scenario.

No.	Comment/Disposition	Response
RT-19	Question RT – 4 was partially answered. The unanswered parts are restated as follows: Hydrogen will be generated when the chilled water system is not being operated, and it will accumulate at any high point in the chilled water pipe loop. Considering all possible sources (including both IX column heat exchangers and other sources), what is the projected maximum volume of accumulated hydrogen in the chilled water system under static conditions? At what rate would vessel CHW-VSL-00024 release this accumulated hydrogen to the C3 area when pumping the chilled water resumes? If this rate is not sufficient to prevent the temporary accumulation of a bubble of hydrogen in CHW-VSL-00024, what controls will protect the facility worker against a possible deflagration inside the vessel? How will the accumulated hydrogen be released to the C3 area such that it will not ignite? ORP Disposition: The response is conditionally acceptable per subsequent informal ORP and BNI agreement to address hydrogen hazards in this system as part of resolving existing Condition of Acceptance (COA) (Item 5[c], Section No. 4.2, of *Safety Evaluation for WTP Construction Authorization*, *ORP/OSR-2003-01*). See Section Dof this SER for specific COAs assigned to this ABAR.	The issue of hydrogen generation and collection within the chilled water system and piping systems not directly related the Cs IX columns falls under BNIs investigation into the elimination of hydrogen collection points. An ongoing activity whose completion requires issued design drawings that provide an accurate representation of the piping designs.
RT-20	New Question 8. Responses to questions RT - 5, - 6, - 9, and - 10 are deferred pending “a thorough investigation of piping that can trap hydrogen” and a review of “design drawings that provide a true representation of the piping”. It appears the issues raised in these questions will not be fully resolved when the ABAR package is submitted for approval. If this is the case, what analyses, design changes, and/or control strategies are under consideration to address the issues?	When the appropriate drawings have been issued with regard to providing an accurate representation of hydrogen collection points in piping, the BNI investigation will address this issue at this time.

No.	Comment/Disposition	Response
	<u>ORP Disposition:</u> The response is conditionally acceptable per subsequent informal ORP and BNI agreement to address hydrogen hazards in this system as part of resolving existing Condition of Acceptance (COA) (Item 5[c], Section No. 4.2, of *Safety Evaluation for WTP Construction Authorization, ORP/OSR-2003-01*). See Section Dof this SER for specific COAs assigned to this ABAR.	
RT-21	The response to RT-7 appears to be based on a misunderstanding of the question. Therefore, the question is restated with additional explanation, as follows: The treated solution from the lead IX column will pass from the base of the lead column upward through a pipe located close to the lead column wall, then to a high point (apex), and then down to the lag column. This pipe will pass within a few feet of the zone of the loaded resin in the lead column. Since this column may be loaded with as much as 150,000 curies of Cs-137, the direct radiation dose rate to the treated LAW solution within the pipe at this location will be significant. When the feed pump is not operating, the hydrogen generated will accumulate in the piping in significant quantities at the high point, depending on the interval of time the feed pump is not operated and the column is left loaded with Cs-137. Significant quantities of hydrogen may be generated and accumulate. What control strategy will be employed to prevent an accumulation of hydrogen in excess of one liter in the pipe? <u>ORP Disposition:</u> The response is conditionally acceptable per subsequent informal ORP and BNI agreement to address hydrogen hazards in this system as part of resolving existing Condition of Acceptance (COA) (Item 5[c], Section No. 4.2, of *Safety*	The issue of hydrogen generation and collection within the ASX system and piping systems falls under an existing open COA; the investigation into the elimination of hydrogen collection points.

No.	Comment/Disposition	Response
	Evaluation for WTP Construction Authorization, ORP/OSR-2003-01). See Section Dof this SER for specific COAs assigned to this ABAR.	
RT-22	The response to RT-11 does not fully address the question, which, restated with further clarification, is as follows: Radiolytic gases will nucleate and grow as small bubbles on the surfaces of the resin particles within the bed when no solution is passing through the column. The resin particles are small enough and the surface tension is high enough that the gas bubbles can increase in volume and remain attached to individual resin particles. Growth of the bubbles will continue until the density of the resin-bubble combination is sufficiently reduced that the resin and bubbles become buoyant, suddenly rise, and release the collected gas all at once. How much time will elapse between automatically or manually shutting off the IX column feed pump and then restarting the pump without eluting the column? How much time will elapse between automatically or manually shutting off the IX column feed pump and initiating (1) normal elution flow and (2) emergency elution flow through the lead column? How much hydrogen can accumulate in a resin bed loaded with 150,000 curies of Cs-137 during these intervals? If greater than one liter, how will the risk of ignitable concentrations of hydrogen be mitigated? <u>ORP Disposition:</u> In a follow-up meeting with the Contractor, the Contractor agreed to evaluate the time the column can be left loaded with resin before initiating normal or emergency elution. The time will likely vary as a function of Cs-137 loading. The agreement is conditionally acceptable pending the Contractor's submittal and ORP acceptance of the Contractor's evaluation of	In a loss of flow event, the hydrogen mitigation system will work as normal. During this period of no flow, BNI does not expect the bubbles to release all at once. Operations may choose to elute the column; however, no time constraint exists for this operation.

No.	Comment/Disposition	Response
	the time (and its basis) the column can be left loaded with resin before initiating normal or emergency elution. See Section Dof this SER for specific COAs assigned to this ABAR.	
RT-23	The sequence shown in “Preliminary Control Scheme – Nitrogen Blanket in CXP System, Rev. 1” seems to leave the resin exposed to 0.5M nitric acid. The SED/PSAR Section 3.4.1.7.1.6 (under “Bounding Environmental Conditions”) states, “Emergency elution of the columns with acid must be followed by a caustic regeneration step to remove the acid from the resin bed. This is necessary to prevent self-concentration of the residual acid in the column by evaporation. Concentrated acid can react at an accelerated rate with the acid causing pressurization of the column.” Will the column be left exposed to acid as the steps in “Preliminary Control Scheme – Nitrogen Blanket in CXP System, Rev. 1” imply, or will elution be followed with caustic regeneration? <u>ORP Disposition:</u> The response is acceptable. The Contractor stated that regeneration will follow emergency elution, thereby placing the column in an acceptable state.	Emergency elution a column will be followed with a caustic regeneration step to remove acid from the resin bed.
RT-24	Step A5 in “Preliminary Control Scheme – Nitrogen Blanket in CXP System, Rev. 1”, dated 5/4/2004 has been changed to “Close valve 6” as indicated in the question. Can we assume this is now correct? <u>ORP Disposition:</u> The response is acceptable. A correction was made.	Yes, this is correct.
RT-25	Section 3.4.1.7.1.6, Single Failure Criteria. The text indicates that	<u>ORP’s Synopsis of Contractor’s Informal Response</u>

No.	Comment/Disposition	Response
	for a "given loss of fluid from the column, caustic fluid or demineralized water would be capable of preventing the IX column resin from becoming exposed and drying out." Please describe the assumed loss of fluid (rate/volume). What is the rate at which fluid would leak out in the case of an accident, e.g., dropped load, load accidentally swung into the side of the column, or mishandling equipment causing a broken remote connector which causes a line to be breached (if any column nozzles are located below the resin level)? In these events, is the rate of emergency fluid leakage higher than PT can accommodate before correcting the damage? Is channeling of emergency fluid additions through the resins in the event of a large breach, resulting in uneluted and cooled areas within the resin bed, possible? If not prevented, how will PT operators deal with a large breach of the IX column? <u>ORP Disposition:</u> The response is acceptable. The Contractor described credible means of dealing with rapid leakage from the columns. A follow-on question (RT-29) addresses the hazards associated with spilled loaded resins due to a column breach.	In the event of a breach in the column where the liquid drains out rapidly (but not the resin), operators will have at least 110 hours to respond before auto-ignition of the resin could occur. The resin could be eluted and/or cooled in place within this timeframe by three methods, depending on the damage incurred: (1) via the waste feed/normal elution line, (2) via the emergency elution/resin addition line, and (3) via the cell decontamination lances, which are capable of being positioned over the breached area. A pipe jumper connected to the base of the IX column that is used to remove spent resin can be removed or loosened to ensure drainage of the acidic eluate from the column. Using the lances with nitric acid decontamination fluid provides a means of eluting the resin in breached areas that may not be reachable with options (1) and (2).
RT-26	How much soot will be generated and load on the PVV/PVP and C5 filters in the event of unmitigated combustion of the resin? In this event, what is the impact on the ability of these ventilation systems to satisfy their safety functions if the combustion event occurs when the filters are already loaded to levels requiring normal change-out? <u>ORP Disposition:</u> The response is acceptable. In the absence of a calculation that shows the PVV/PVP and C5 filters can withstand the soot loading in the event of the resin fire, the reviewers agree	We have no way of characterizing the soot loading because the resin properties are proprietary. Thus, due to the amount of resin potentially available we have to assume there is no effective mitigative strategy that will inhibit the failure of the C5 ventilation system during the fire event. Therefore, this event must be prevented. This is accomplished by utilizing the following controls that precludes the resin from overheating and resulting in a fire event: 1. IX column confinement boundary.

No.	Comment/Disposition	Response
	with the Contractor that this event must be prevented. See RT-29 for further discussion of this issue.	2. Cell concrete structure and C5 Ventilation system. 3. Emergency Elution. 4. Column temperature monitoring indication. 5. Flooded column level detection Switch, LS-4*.
RT-27	Section 3.4.1.8. How much time is required for an air-exposed, fully loaded resin bed to generate explosive levels (>4%) of hydrogen in the column headspace due to radiolysis of residual fluids and the resin following a fluid leak from the bed? Why is this event not included with the six representative events shown? It is noted that the following sentence was deleted from Section 3.4.1.8.4, "Hydrogen can accumulate in a cesium ion exchange (Cs IX) column, resulting in a potential deflagration or detonation." Also please provide the time need to detect the leak and to complete emergency elution. ORP Disposition: The response is acceptable. The Contractor has identified controls for preventing hydrogen accumulations in the column headspace in the event of a leak in the column.	ORP's Synopsis of Contractor's Informal Response A slow to moderate leak rate (e.g., through the spent resin removal jumper fitting) will be detected at L3 and L4; emergency elution then will be automatically implemented and completed in less than a day. This will minimize the possibility that explosive gases will form in the resulting column headspace created when subsequent drainage exposes the resin to air. The nitrogen inerting system can be used immediately, if necessary, to sweep hydrogen from the column safely to the cell through the leak location.
RT-28	Section 4.4.17.5, System Evaluation. Please explain the rationale for not including an interlock to shut off the Cs IX feed pump when either the column inlet or feed pump isolation valves are closed. ORP Disposition: The response is acceptable. The Contractor notes that the pump will be shut off automatically by the process control system rather than the ITS PPJ system since the pumps are not credited with a safety function.	The Cs IX feed pumps has a process control via the ICN that shutdown the pumps on low flow. Hence, the pumps are not credited with a safety function; therefore, no interlock was included in 4.4.17.5.

No.	Comment/Disposition	Response
RT-29	A previous question (RT-25) addressed the consequences of breaching an IX column in a maintenance accident, resulting in draining the column, and drying out and self-heating the resin, potentially causing a fire that could produce enough soot to overwhelm the C5 HEPA filters. A follow-on discussion with Peter Omel of BNI resulted in clarifying the question to include the possibility that a large breach could cause the resin to spill out onto the floor in a pile, where the resulting resin fire would not be extinguished by simply passing water through the column. Mr. Omel requested Gregory Fenton for an assessment of the ability of wash wands in the cell to be used to clean up the spilled resin. Mr. Fenton responded, "We do have wash lances in the hot-cell for decontamination purposes. The P&IDs that show the area of the hot-cell in question are 24590-PTF-M6-PWD-00022 and 24590-PTF-M6-PWD-00045." Since this response is too incomplete to ascertain likely effectiveness of the control, please answer the follow-on questions. • Since the IX columns are spread out over a considerable distance in the cell, are these lances located near enough to the columns to be effective and how will they be used to either put out the fire before excessive soot loading of the filters occurs, or to sluice the resin to a location where a fire will not occur? (Presumably the resin would not be sluiced to a sump since the sump could dry out, which may result in a fire.) • If the intent is to sluice the loaded resin to a vessel (or possibly to a sump followed by pumping to the vessel), how is the vessel protected against the possible accumulation of hydrogen in its head space? <u>ORP Disposition:</u> The response is acceptable. The Contractor has identified controls to mitigate the hazards associated with spilled	<u>ORP's Synopsis of Contractor's Informal Response</u> Four decontamination lances located within the hot cell are capable of being positioned over and around the IX columns. These lances are capable of spraying decontamination acid onto the spilled resin to elute it in place, or water to cool the resin to avoid resin dry-out, self-heating, and eventual auto-ignition. The lances can also be used to flush the spilled resin to the cell sumps where the collected resin can be pumped to the _ System for recycling. The sumps can be kept submerged to prevent the resin from drying out until all of the resin has been transferred to the _ System. The _ System is designed to accommodate the direct radiation and hydrogen generation rates caused by the design-basis loaded resin (150,000 Ci Cs-137).

No.	Comment/Disposition	Response
	resin, thereby preventing a resin fire.	
RT-30	A previous question (RT-13) addressed the possibility that hydrogen could collect in dead legs of the IX column hydrogen mitigation system. Peter Omel asked John Olson to respond, who did so as follows: “We will ensure that all pipe connections in CRP-BULGE-00001 to the stream path from the columns are at 90-degrees to ensure bubbles don't collect in side lines.” Certain 90-degree orientations would result in collecting hydrogen. Please confirm that the following underlined change to Mr. Olson’s response is as he intends: “We will ensure that all pipe connections in CRP-BULGE-00001 to the stream path from the columns are at 90-degrees <u>to and feeding vertically up into the hydrogen mitigation pipeline</u> to ensure bubbles don't collect in side lines.” <u>ORP Disposition:</u> The second response is acceptable. The Contractor has committed to ensure the preferred pathway for gas migration is to the hydrogen mitigation system rather than to the dead legs found in the current design.	First Response: We will ensure that all pipe connections in CRP-BULGE-00001 to the stream path from the columns are at 90-degrees to ensure bubbles don't collect in side lines. Second Response: The bulge piping will be sloped such that gas is preferentially directed to the hydrogen mitigation portion of the pipe. This generally means that branches between the preferred pathway and other branches will be made in tees inline with the pipe slope. Where the preferred pathway reduces from a larger pipe-size to a smaller pipe-size, the branch to the preferred pathway will be taken off the top instead off the side. This will ensure that the preferential gas pathway is always to the hydrogen mitigation system.
RT-31	During the August 11 meeting, it was reported that a “football-sized” release of hydrogen could occur suddenly from the column when the flow of liquid waste through the column was suddenly ceased, and that the column’s hydrogen mitigation system was designed to accommodate this release. BNI committed to providing an analysis that documented the basis for the “football-sized” release. The following extract from CCN 083647 was provided by BNI in response:	As documented in CCN 075614, Research and Technology (R&T) identified that, while the average gas generation rate may be predicted by the calculation, laboratory experience is that gas bubbles are trapped in the IX resin and are usually released during elution as large bubbles. Unfortunately, there is no documentation of this phenomena, nor quantification of the size of these bubbles. Observations indicate that bubbles in the half-scale IX column were about the size of a "football".

No.	Comment/Disposition	Response
	"However, for purposes of sizing the siphon break, a more conservative bounding assumption is made that one liter of gas in excess of the hydrogen mitigation system's inerting capacity is released from a column at the maximum system operating pressure (85 psig)." The above statement provides an assumption that an extra one liter of gas could be released, which is about the size of a small football. However, no basis for the one-liter release is provided. It appears to the reviewer that the size of the release is related to the time of exposure of the waste, the relative real densities of the waste and resin (which affects buoyancy of the resin with small bubbles attached to it), the fraction of the bed that may suddenly roll over and release the attached bubbles, and the time and effectiveness of elution after flow of waste has ceased. <u>ORP Disposition:</u> The response is conditionally acceptable pending the Contractor's submittal and ORP acceptance of the Contractor's evaluation of (1) the maximum bubble size and rate for bounding conditions (e.g., stopping the elution pump just as the fully loaded resin is exposed to elution acid and (2) assessing the impact of the maximum bubble size and rate on the safety of the current hydrogen mitigation system design. See Section Dof this SER for specific COAs assigned to this ABAR.	Further, bubbles were not observed every elution cycle, but they were observed often. Action item #2, for R&T to document bubble information (size and rate) has not been completed.
RT-32	The response to RT-22 does not fully address the question, which, restated with further clarification, is as follows: Radiolytic gases will nucleate and grow as small bubbles on the surfaces of the resin particles within the bed when no solution is passing through the column. The resin particles are small enough and the surface tension is high enough that the gas bubbles can increase in volume	<u>ORP's Synopsis of Contractor's Informal Response</u> The issues associated with the accumulation of hydrogen within loaded columns upon loss of pumping have not been fully analyzed. However, if necessary, the capability to immediately elute the resin exists through the normal and emergency elution systems. The time allowed

No.	Comment/Disposition	Response
	and remain attached to individual resin particles. Growth of the bubbles will continue until the density of the resin-bubble combination is sufficiently reduced that the resin and bubbles become buoyant, suddenly rise, and release the collected gas all at once. • How much time will elapse between automatically or manually shutting off the IX column feed pump and then restarting the pump without eluting the column? • How much time will elapse between automatically or manually shutting off the IX column feed pump and initiating (1) normal elution flow and (2) emergency elution flow through the lead column? • How much hydrogen can accumulate in a resin bed loaded with 150,000 curies of Cs-137 during these intervals? If greater than one liter, how will the risk of ignitable concentrations of hydrogen be mitigated? ORP Disposition: The Contractor notes that immediate elution can be conducted if necessary to avoid unacceptable hydrogen buildup. A basis for delaying elution while troubleshooting or waiting for lost power to resume is yet to be established. The Contractor's response is conditionally acceptable pending the Contractor's submittal and ORP acceptance of the Contractor's evaluation of the time the column can be left loaded with resin before initiating normal or emergency elution. See Section Dof this SER for specific COAs assigned to this ABAR.	between cessation of pumping and starting elution, which will be a function of the loading level and possibly other factors, will be evaluated.

No.	Comment/Disposition	Response
GR-1	Table 2 and Figure 1 give resin doses as a function of the Cs-137 loading. Figure 2.5-7, p. 2.5-74, in 24590-WTP-RPT-PT-005, Rev. 2, presents data similar to Figure 1, but the doses are about a factor of 8 higher in Figure 2.5-7 for equivalent Cs-137 loadings. Why was Figure 1 used as a basis for these calculations rather than Figure 2.5-7? <u>ORP Disposition:</u> Use of the micro-shield calculations to calculate radiation-absorbed dose by the resin is acceptable.	The referenced figure presents a "Simplified Resin Bed Absorbed Dose Rate Estimate" based on 100% of the available energy absorbed by the resin bed. The resin dose data in question are determined from micro-shield calculations of radiation-absorbed-dose by the resin at the specified loadings.
GR-2	On sheet 6 it is stated that the gas generation rate will be highest for the nitric acid/resin combination rather than LAW/resin, caustic/resin, or water/resin. For hydrogen generation rates, the water/resin system would be expected to yield higher rates than the LAW/resin and acid/resin systems because the nitrate/nitrite ions in LAW and nitric acid solutions suppress the hydrogen generation rate. Do the test results support the above statement for total gas generation rate, i.e., the nitrate/nitrite only suppresses hydrogen generation and not other gases? <u>ORP Disposition:</u> The test data were reviewed and the data show that the total gas generation rate is highest when the resin is in contact with nitric acid. Therefore, the response is acceptable.	While it is correct that nitrate/nitrite suppression occurs in LAW and water will not exhibit this suppression, the chemical oxidation of the organic resin by nitric acid results in greater gas generation rates than in other fluids because acid attacks the organic resin. Water will not attack the resin as nitric acid does; therefore, the gas generation rate will be highest in nitric acid. Test data indicate that gas generation with nitric acid is almost an order-of-magnitude greater than LAW. See response to question 7 for a comparison between the rates calculated in this method versus other methods.
GR-3	The basis for gas generation for the water/resin system is stated in Table 4 as using data for water and resin separately and summing them at a 3:1 ratio. How certain are you that this approach is valid compared to obtaining radiolysis data for the combined system?	This is the only available data for these resin/fluid matrices coupled with radiation exposure. It is known that resin in water will generate more gas than in LAW feed and less than resin in nitric acid, thus the total gas generation rate for water is bounded by the gas generation rate in nitric acid. The total gas generation rate will also

No.	Comment/Disposition	Response
	<u>ORP Disposition:</u> While not having the data is an unsatisfactory response, it is acceptable in this case because the total gas generation rate was shown in the laboratory tests to be much higher for the nitric acid/resin system than any other combination. Therefore, obtaining the data for the water/resin combination would not cause the total gas generation rate to exceed that for the nitric acid/resin system.	be assumed (in the worst case) as all hydrogen to size the air purge rate to the requisite siphon-breaks.
GR-4	The basis for maintaining a non-flammable gas composition in the collection chamber is to keep the oxidizer concentration below 6 % (sheet 12) by periodic purging with nitrogen gas. Depending on the process conditions, the hydrogen concentration could be 20 to 60% of the total gas generated (sheet 5). (It would be desirable to show the hydrogen generation rates in Table 4). Will the mixture, which results from using 6.33 volumes of nitrogen per volume of the total gas generated, always remain non-flammable when mixed with air in the PVV? <u>ORP Disposition:</u> The response is acceptable assuming instantaneous releases of more than the one-liter of flammable gas basis-of-design do not occur. See RT-31.	The referenced report indicates, "*for a hydrogen-air-nitrogen system, a reduction of oxygen concentration to below 6 percent is required to reach the nonflammable range*." Thus, the mixture collected will be controlled to meet this requirement. Further, the siphon break where this gas is vented is sized to instantaneously dilute a pure hydrogen bubble greater than the normal gas collection volume. Therefore, even if the gas is pure hydrogen, it will be diluted to less than one volume percent upon entering the siphon break.
GR-5	What will be the frequency for the nitrogen purges and how much gas will be generated between purges? <u>ORP Disposition:</u> The response is acceptable.	That will depend on the size of the collection system. An initial design estimate is for purges about every 30 minutes under normal conditions. Gas generation between purges will be exactly the collection volume (which drives purges). Preliminary collection volume size is about 0.7 liters.
GR-6	The maximum safety case temperature is given on sheet 9 as 113	The Emergency Elution system will be required to actuate

No.	Comment/Disposition	Response
	^{o} F, which is the maximum hot cell temperature assuming no temperature control. What maximum temperature would the IX Column loaded with 150,000 Ci of Cs-137 reach from self-heating upon loss of cooling? Will the emergency elution system be Safety Design Class and be available to elute the column to prevent achieving temperatures higher than 113 ^{o} F? <u>ORP Disposition:</u> The response is acceptable as the emergency elution system is stated in the updated PSAR to be Safety Design Class.	if a column looses flow for a specified time (based on this heat up), but the time has not been defined yet.
GR-7	On sheets 13-15 scaling of laboratory test results to IX conditions is done to determine gas generation rates in the IX columns as a function of Cs-137 loading. How does this approach compare with the method used in previous hydrogen generation calculations to determine the generation rates using G-values from radiolysis of the various fluid/resin systems? Were G-values determined for the gases produced from radiolysis? <u>ORP Disposition:</u> The response is acceptable as it is shown to be more conservative than using G-values	A comparison was made with the method used in 24590-WTP-M4C-V11T-00004, Rev A, *Calculation of Hydrogen Generation Rates*, which uses the G-value approach. That approach resulted in the following hydrogen generation rates (using very conservative heat load of 0.177 W/L): Env B (45° C, 150,000 Ci): 0.65 L/hr LAW | 3.1 L/hr water Env B (25° C, 150,000 Ci): 0.45 L/hr LAW | 2.9 L/hr water In comparison, this calculation results in the following hydrogen generation rates (assuming the maximum hydrogen fraction: 67%): Env B (45° C, 150,000 Ci): 1.4 L/hr LAW | 18 L/hr nitric Env B (25° C, 150,000 Ci): 1.0 L/hr LAW | 4.1 L/hr nitric This calculation method results in larger gas generation rates than those predicted using the approach in previous

No.	Comment/Disposition	Response
		hydrogen generation calculations. This is because previous methods did not consider an organic resin/fluid matrix and thermolysis is the dominant form of gas generation. Therefore, using G-values from other calculation methods is not useful in estimating the gas generation rates in ion exchange columns.
GR-8	The gas generation rates in the cesium ion exchange columns are based on data from the irradiation and thermal experiments reported in WTP-RPT-024, January 2003. In reviewing this report, the irradiation tests were performed in closed systems and the gas generated was determined at the end of each irradiation time period at a dose rate of 5.5×10^5 R/hr. It is noted that at short irradiation times (<20 hours) the average gas generation rate given in Tables 18 and 26 in this report generally give higher rates (before equilibrium is established?) than at long irradiation times (>140 hours). G-values for the various gases being generated (including hydrogen, nitrogen, oxygen, nitrous oxide, methane, and hydrocarbons) are given in Table 27 based on the data for the long irradiation times. For example, the G-value for hydrogen in water is given as 0.196 molecules/100 eV (the average of three measurements at three temperatures for >140 hours) and the discussion on page 3.26 says that this value for pure water in a closed system is consistent with literature values established for this system. For open systems where hydrogen is being removed as it is generated, the G-value is generally accepted as 0.45 molecules/100 eV. Since the Cs IX column will not be a closed system (gas generated is periodically accumulated and released through the hydrogen mitigation system), why are experimental data for a closed system applicable to the Cs IX	The hydrogen gas generation rates used by BNI were chosen to be those at 1E8 rad (exposure duration of 147 hours) because these values cover the range of temperatures required (77^o and 113^o F) and the 147-hour duration experiments most closely mimic the expected chemical/thermolysis reactions. Even though this generation rate is lower than the 1.47 hour test data it was determined to be adequate because the rate at which the ITS purge air is supplied is based on total gas generation, not hydrogen gas generation rate (Note for both circumstances the H2 generation is essentially constant). The same can be said with regard to open/closed systems issue, during normal operations we feel that we have a closed system and when initiated its open (Note that while gas generation changes, the hydrogen generation rate does not change). At the higher gas generation rate, an increase in valve cycling (purges of the hydrogen mitigation system) would be seen for operations at the 150 k curie TSR limit.

No.	Comment/Disposition	Response
	system? Why aren't the short-term gas generation rates used since they may be more typical of an open system? ORP Disposition: The ORP reviewer does not agree with the BNI position that the Cs IX system is a closed system rather than an open system. Thus, the laboratory test data based upon a closed system may not be conservative because hydrogen generation rates may be higher in an open system than in a closed system. Also, the short-term test data may be more representative than the long-term test data in predicting hydrogen generation rates in the columns. However, the reviewer will accept the non-conservative test data because of the very large degree of conservatism in the methodology for applying the data, i.e., a nitrogen inerting system based upon a minimum of 4.8 liters of nitrogen per liter of total gas generated and an ITS air purge rate to maintain less than 4% hydrogen based upon the total gas generated (not on hydrogen generated). Since the hydrogen fraction of the total gas generated for the nitric acid/resin system was less than 0.06 at 113 F (safety case conditions), there will be sufficient nitrogen and air dilution to more than account for an expected potential factor of 2 to 3 greater hydrogen generation rate for an open system.	
GR-9	Sheet 11 of the most recent draft Calc. No. 24590-PTF-MVC-CXP-00015, Rev. A, states that G-values from Table 27 of WTP-RPT-024 were used to show that the total gas generation rate is greatest with nitric acid (0.80 mole/kg-day) compared to water (0.28 mole/kg-day) and LAW feed stimulant (0.10 mole/kg-day). How were these results calculated from the G-values? Were the thermal gas generation rates included in the	The example in question provides a comparison of the total gas generation rate by addition of G-values listed in Table 27 of WTP-RPT-24; however, the units listed should be molecules/100eV not mole/kg-day. The values reported are the sum of G-values for each gas. This example is used to show the reader that gas generation from water is bounded by the gas generation from nitric

No.	Comment/Disposition	Response
	above numbers? ORP Disposition: The response is acceptable as the errors are corrected.	acid.
GR-10	Section 8, Sheet 25, of the above calculation document does not appear to be updated to the revised data presented in the latest version. For example, shouldn't the 6.33 liters of nitrogen, which was determined in the previous draft, be replaced by 4.8 liters of nitrogen determined in Section 7.2 of this draft? Also, shouldn't both Figures 6 and 7 be referred to in items 2 and 3 rather than just Figure 6 (Figure 7 was added in this draft)? ORP Disposition: The response is acceptable as the error will be corrected.	Correct. This error is being corrected in the checking process for this draft document.
GR-11	A memorandum (CCN: 083647) dated April 20, 2004 gives the basis for sizing the siphon break in the CXP system. The memo states that all hydrogen generated in the Cs IX column is likely to be dissolved in the LAW solution (the solubility was calculated to be 0.64 mg H_2/L LAW feed for Envelope B). As a result no hydrogen bubbles are expected to be formed in the column. On page 3 of the memo, it is, nevertheless, assumed that one liter of gas in excess of the hydrogen mitigation system's inerting capacity is released from a column at the maximum system operating pressure of 85 psig. What is the basis for the 1 liter volume? How much soluble gas would be released from the column if it became depressurized to 1 atm by failure of the feed pump and/or the column itself?	If the column is depressurized as result of an accident such as broken pipe, or column leak, L4 will detect gas due to the loss of liquid within the hydrogen mitigation system. The pumps to the columns will be turned off and the system will be passively vented via redundant pathways out of the column to a purge air supplied siphon break. The depressurization of the column, due to the pumps being turned off would be expected to release any hydrogen that might be trapped in the resin bed. For normal operations where LAW is transferred through a siphon break, resulting in the release of dissolved gases to the siphon break at 1-atm pressure. The siphon break will be purged based on the total gas generation rated as discussed in question one. Once the system has gone into

No.	Comment/Disposition	Response
	ORP Disposition: The response is acceptable.	this bypass mode, operator monitoring and column temperature would dictate the need to perform emergency elution. If initiated the contents of emergency elution (sodium hydroxide, water, and nitric acid) will be transferred to the eluant contingency storage vessel CNP-VSL-00003 via siphon break CXP-HR-00026-S11B-06 and break-pot CNP-BRKPT-00001.
GR-12	This memorandum determines the size of the siphon break assuming that the air dilution must reduce the hydrogen concentration to below 4 percent. Everywhere else in the WTP the dilution criterion is to dilute to below 1 percent. Why is 4 percent used in this calculation? ORP Disposition: For off-normal conditions the concentration limit of 4 percent is acceptable.	For normal operations, a hydrogen concentration limit of 1 percent is used. For off-normal conditions, as one-liter gas bubble, a hydrogen concentration limit of 4 percent is used.
GR-13	A memorandum (CCN: 083650) dated April 20, 2004, gives the bounding basis for nitrogen use in the CXP Hydrogen Mitigation System. On page 1, the above calculation document was referenced as the basis to use 10 liters of nitrogen per liter of generated gas in order to inert the gas (make it nonflammable). However, the referenced report gives a value of 4.8 liters of nitrogen required per liter of gas generated. Has an additional factor of two been applied, and, if so, what is the basis? ORP Disposition: The bounding ratio is acceptable because it exceeds the requirement to use a minimum of 4.8 liters of nitrogen per liter of gas generated.	Please note that these memos define bounding conditions to be used in lieu of design calculations. The 10:1 ratio is a bounding ratio. The nitrogen:gas ratio will be refined in the piping design after the hydrogen generation calculation is completed.

No.	Comment/Disposition	Response
BV-1	What is the system failure frequency of the IX hydrogen mitigation system? Also, what is the expected failure frequency due to valve failures? ORP Disposition: The response is conditionally acceptable. The reliability of the safety function and normal operation of the purge system may not be adequate based on the preliminary application of generic valve failure data. Valve failure data more specific to the high-demand power-operated valves should be obtained and the overall reliability of the purge system in performing its safety function should be quantified. See Section Dof this SER for specific COAs assigned to this ABAR.	The commercial nuclear industry has become one of the primary sources for failure rate data because it is one of the few industries which have mandated the collection of failure rate information under a prescribed set of conditions. At first, to ensure that unreliable components could be identified and later to provide s a source of information for the quantification of reliability models used in nuclear plant risk assessments. The data have several major sources: • Nuclear Computerized Library for Assessing Reactor Reliability, NUCLARR (USNRC) • LER data base and the results from its analysis by the AEOD (USNRC) • INPO data base (Industry), superceded by EPIX (Industry). However, it is their commonality that is important. All of the demand failure rates provided in these reliability data bases are generally predicated on a monthly test interval, virtually the standard in the commercial nuclear industry until relatively recently The general formula for calculating demand failure rates indicates that, for a range of demand failure rates, they are a direct function of component test interval. This means that if the failure-on-demand from nuclear derived data bases are used in calculating the demand reliability for standby systems with differing test intervals, compensation must be taken. In the case of the hydrogen purge system, each of the valves will be cycled at least once every 8 hours, and since

No.	Comment/Disposition	Response
		the valves will have self-diagnostic monitoring, each demand is, in effect, a test. This implies that the demand failure rate provided in the published data for air operated valves, 3E-03 /demand must be adjusted appropriately, i.e. multiplied by a factor of 0.011, (ratio between the number of monthly tests per year and the number of tests when performed each shift). This produces a more realistic value of 3.3E-05 /demand. Demand or Operating Data There is always the question as to whether component demand data are appropriate for use when the component is demanded frequently as a normal part of system operation. This is because the failure causal mechanisms tend to change as the demand frequency increases. • In a system which is used infrequently, the dominant causes of failures tend to be associated with corrosion, stiction and increased friction caused by loss of lubricating films on moving surfaces. • In a system which is used frequently, the cases of failure tend to be more related to fatigue (induced by temperature or mechanical cyclic loading) Since these mechanisms tend to be different in nature there is a transition range where the dominant causes of failure change. This is the point that demand failure rates transition to operating failure rates. Unfortunately the transition point is not well characterized (once per hour, per shift, per day?). In this case it is best to perform the

No.	Comment/Disposition	Response
		calculation each way and then make a judgment. Quantified Comparison: If a valve is operated once per shift (8 hours) • Demand failure probability is 3.3E-05. When it is demanded once per shift: • Annual failure frequency becomes ~0.04 /yr (Failures/yr = (Failures/test * tests/yr) 3E-05 failures/test *8760 hrs/yr / 8 hr/test) ~ 0.04 failures /yr . When this same valve is treated as a normally operating component the published failure rate is 3E-06 /hr (spurious operation) • Annual failure frequency ~ 0.03 /yr (Failures /yr= Failures/hr * hrs/yr) 3.3E-6 failures/hr * 8760 hrs/yr ~ 0.03 failures /yr This would indicate that for the current assessment, either method would be acceptable. However this insight does also provide a measure of support for the use of a demand failure rate which is on the order of 3E-05 /demand, not the "as is"3E-03 / demand value taken directly from the data base. ORP's Synopsis of Contractor's Informal Responses Component demand data may not be appropriate for use in the reliability analysis when the component is demanded frequently as a normal part of system operation. The reliability of the system in performing its safety function (preventing flammable hydrogen accumulations) is

No.	Comment/Disposition	Response
		qualitatively judged to be adequate because, • The control system will be designed to detect and diagnose failures of the system and automatically activate a continuous vent path on failure. • If a flammable concentration of hydrogen did occur and ignite, the consequences would be small and mitigated by the secondary confinement system, which includes the cell structure and the C5V system. A formal analysis of the reliability of the system for the Operations Risk Assessment (ORA) will be performed.